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VA DEPARTMENT OF ENVIRONMENTAL QUALITY
NORTHERN
MAY 29 2015
REGIONAL OFFICE
WOODBRIDGE, VA

May 26, 2015

Thomas A. Faha
Department of Environmental Quality
Northern Regional Office
13901 Crown Court
Woodbridge, VA 22193

Dear Mr. Faha:

Enclosed for your review is the Annual Report for Lake Anna, Waste Heat Treatment Facility, and the Lower North Anna River for 2014. The data indicates that Lake Anna and the Lower North Anna River continue to support a well-balanced ecological community and both remain some of the finest recreational resources in Virginia.

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Please let me know if you have any questions concerning this information as well as any other ongoing environmental monitoring for North Anna Power Station.

Sincerely,

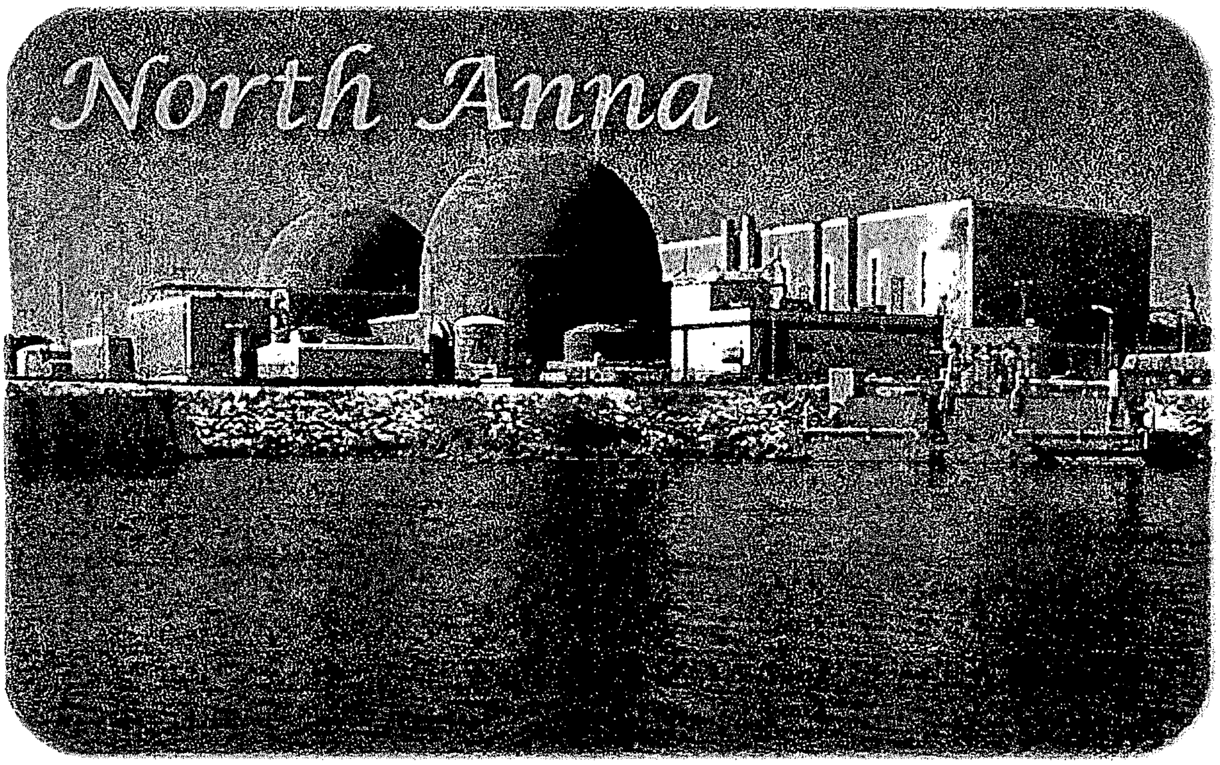
Cathy C Taylor

Cathy C. Taylor
Director – Electric Environmental Services

cc: w/enclosure
Mr. John Odenkirk
Virginia Department of Game and Inland Fisheries
1320 Belman Road
Fredericksburg, VA 22401

ENVIRONMENTAL STUDY OF LAKE ANNA, WASTE HEAT TREATMENT FACILITY AND THE LOWER NORTH ANNA RIVER

ANNUAL REPORT FOR 2014



Prepared by:

ENVIRONMENTAL BIOLOGY

ELECTRIC ENVIRONMENTAL SERVICES

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Executive Summary

This report presents the findings of various ecological studies conducted by Dominion biologists in 2014 on Lake Anna (lake), the Waste Heat Treatment Facility (WHTF) and the North Anna River downstream of the dam. The studies were conducted in accordance with the 2014 study plan that was approved by the Department of Environmental Quality (DEQ) and the Virginia Department of Game and Inland Fisheries (DGIF). The 2014 studies were performed to address the requirements of the NPDES permit for North Anna Power Station and continue to support the 316(a) demonstration for the station.

North Anna Power Station operated at an average of 99.7% for Unit 1 and 92.0% for Unit 2 of net megawatt generation capacity in 2014. For approximately 8 days, Unit 1 was shut down from December 23, 2014 into January 1, 2015. Unit 2 was shut down for approximately 1 day on February 2, and for approximately 33 days from September 7 through October 9, 2014.

The maximum hourly water temperature recorded in 2014 was 37.6°C in July at station NADISC1, located in the WHTF and the minimum was 1.9°C in January at station NAL208T, located in the lake. The maximum and minimum hourly temperatures recorded in the WHTF and lake are within the range of previously reported (years: 1981-2013) maximum and minimum temperatures. In addition to hourly temperature monitoring, standard physicochemical measurements (water temperature, dissolved oxygen, pH, and conductivity) were recorded at the time of biological sampling and were within the values to support a healthy fishery.

In the quarterly lake gill net samples, White Perch, Threadfin Shad, Channel Catfish and Striped Bass had a catch per unit effort (CPUE) that was significantly higher than the 1981-2013 CPUE average. Gizzard Shad CPUE for 2014 was higher than the historical average but the difference was not significant. In the quarterly WHTF gill net samples, Channel Catfish, Gizzard Shad, and White Perch had a CPUE that was significantly higher than the historical average. Striped Bass CPUE was higher than the historical average but the difference was not significant. Largemouth Bass had a CPUE that was significantly lower than the historical average. White Perch, Threadfin Shad, Channel Catfish, Striped Bass, Gizzard Shad and Largemouth Bass have commonly ranked high in the gill net catches in the lake and WHTF.

In 2014, Centrarchids (sunfishes) continue to be the numerically dominant fish taxa collected by quarterly electrofishing surveys in the lake and WHTF. In the lake, Threadfin Shad and Green Sunfish had a 2014 CPUE that was significantly higher than the 1981-2013 average and Redbreast Sunfish's CPUE was significantly lower than the historical average. The differences between Bluegill and Redear Sunfish and their historical averages were not significant. In the WHTF, Green Sunfish, Redear Sunfish, Largemouth Bass and Channel Catfish had a CPUE that was significantly higher than the 1981-2013 average; Bluegill had a catch rate that was not significantly different than the historical average. Overall, 2014 gill netting and boat electrofishing results demonstrate a balanced, indigenous fish community exists in the lake and WHTF; and that physicochemical parameters were within the ranges to support a healthy fishery.

As for the North Anna River below the dam, the maximum recorded temperature at station NAR-1 in 2014 was 31.9°C in July. North Anna River electrofishing surveys typically occur three times a year, in May (survey 1), July (survey 2) and September (survey 3) and utilize electric seine and backpack electrofishing. The May electrofishing samples were not conducted in 2014 due to rainfall, high water and unsafe river conditions. The CPUE for the electric seine on surveys 2 and 3 in 2014 were 233.5, and 164 respectively. CPUE for both electric seine surveys in 2014 were significantly higher than the 1990-2013 historical means. The CPUE for the backpack on surveys 2 and 3 in 2014 were 14.3 and 21.8 respectively. CPUE for both backpack surveys in 2014 were significantly lower than the 1990-2013 historical means.

Electrofishing CPUE in the North Anna River is highly variable. Although 2014 electrofishing CPUE was higher on some surveys and lower on others; species richness has remained high in the North Anna River samples which are indicative of a diverse fish community.

Young of year (YOY) Smallmouth Bass sampling and otolith aging were conducted in 2014 to investigate Smallmouth Bass spawning, recruitment and to examine the influence of the North Anna River flow and water temperature on spawning duration. Smallmouth Bass were collected using a Zodiac electrofisher comprised of a Mark II Zodiac boat outfitted with a Smith-Root Type VI-A control box, single boom umbrella array and a 5000W Honda generator.

Fifty-nine (59) YOY Smallmouth Bass were collected in 2014 and age data derived from them were compared to the dataset from 2008-2013. Seventy-eight percent (78%) of the YOY that were collected in 2014 were spawned when river flows were less than or equal to 400 cfs. Although river flows differed among all four years, the majority of the spawning occurred when flows were maintained at a fairly consistent level at or below 400 cfs during the spawning season.

Biological systems are highly complex and are influenced by many environmental factors. It is difficult to determine exact causes of changes seen in sampling results especially since there are many natural shifts in reproduction, growth, survival and distributions of aquatic organisms. Overall, the 2014 data (species richness, water quality and relative abundance of fishes) indicate that the lake, WHTF and river downstream of the lake continue to support a diverse, healthy, and balanced fisheries community.

River water temperatures were used to assess the potential effects of water temperature on spawning success in the North Anna River. The accumulation of heating degree days (degree days) greater than 10°C was examined in relation to the beginning of the Smallmouth Bass spawning seasons in 2008-2014. Smallmouth Bass spawning is known to begin "when water temperatures exceed 15°C and degree-days greater than 10°C exceed 350" (Tringali 2015). On the North Anna River, the data shows spawning also beginning in each year when water temperatures exceeded 15°C, but four out of six years showed spawning occurring with degree-days less than 350 with an overall average of 283.2 degree-days. Since Smallmouth Bass are known to inhabit both lakes and streams and have northern and southern populations, the 350 degree-days is general to the species and may not represent specific populations.

In addition to the YOY analysis, data for adult and juvenile Smallmouth Bass caught on 10/16/2014 during the fall population sample at NAR-5 were analyzed. In 2014, 48 bass were collected at a rate of 25.4 fish per hour of electrofishing. When plotted the Smallmouth Bass lengths were normally distributed. Fifty percent (50%) of the bass fell into the 175-225 and the 225-275mm length classes with a combined catch rate of 12.7 fish per hour. YOY Smallmouth Bass fell into the 25-75 and 75-125 length classes and had a combined catch rate of 7.9 fish per hour. Smallmouth Bass in the 125-175 length class is missing from the catch in 2014. This missing group is comprised of age-1 bass. This year class would have been represented by the YOY catch in 2013 (2.1) and validates the effectiveness of the population surveys to provide a relative abundance of the different size classes of Smallmouth Bass. Boat electrofishing surveys will be continued and are intended to provide annual catch rates to gage year class strength. As the dataset expands through annual surveys, we should begin to better understand what factors may be affecting the spawn and recruitment of Smallmouth Bass in the North Anna River.

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1.0 Introduction

In 1972, the North Anna River was impounded to create Lake Anna, a 3885 hectare

(9600 acres) reservoir (lake) that provides condenser cooling water for the North Anna Power Station (NAPS). Adjacent to Lake Anna is a 1376 hectare (3400 acre) Waste Heat Treatment Facility (WHTF) that receives the cooling water and transfers excess heat from the water to the atmosphere before discharging into the lake.

Aquatic monitoring studies have been conducted on Lake Anna, the WHTF and the North Anna River below the dam since their inception. In January, 1984, the Company initiated an extensive Section 316(a) demonstration study (P.L. 95-500) to determine if proposed effluent limitations on thermal discharges from the power station were more stringent than necessary to assure the protection and propagation of a balanced, indigenous community of shellfish, fish and wildlife in Lake Anna and the lower North Anna River. The final report (Virginia Power 316(a) Report 1986) successfully demonstrated that the operation of the power station had not resulted in appreciable harm to the biological community. The Virginia Water Control Board (VWCB) accepted the study as a successful demonstration in September, 1986.

Subsequent to the 316(a) study, the Company committed to continue selected environmental studies on Lake Anna, WHTF and the lower North Anna River as part of a post-316(a) agreement. A new VPDES permit for NAPS (permit VA0052451) was issued in May of 2014. In accordance with, "Section E, Post 316(a) monitoring", a Department of Environmental Quality (DEQ) approved monitoring plan was created and implemented in 2014 which is based on historical studies. A report summarizing data from each year is prepared and submitted to the Virginia Department of Environmental Quality (DEQ) and the Virginia Department of Game and Inland Fisheries (DGIF). This report presents the findings for calendar year 2014.

2.0 Station Operation

North Anna Power Station operated at a factor of 99.7% for Unit 1 and 92.0% for Unit 2 of net megawatt generation capacity in 2014. Unit 1 was shut down for approximately 8 days in 2014 from December 23 through the end of the year and into January 1, 2015. Unit 2 was shut down for approximately 1 day on February 2, and for approximately 33 days from September 7 through October 9, 2014 (Figures 1 and 2).

Figure 1 2014 North Anna Unit 1 Daily Power Level

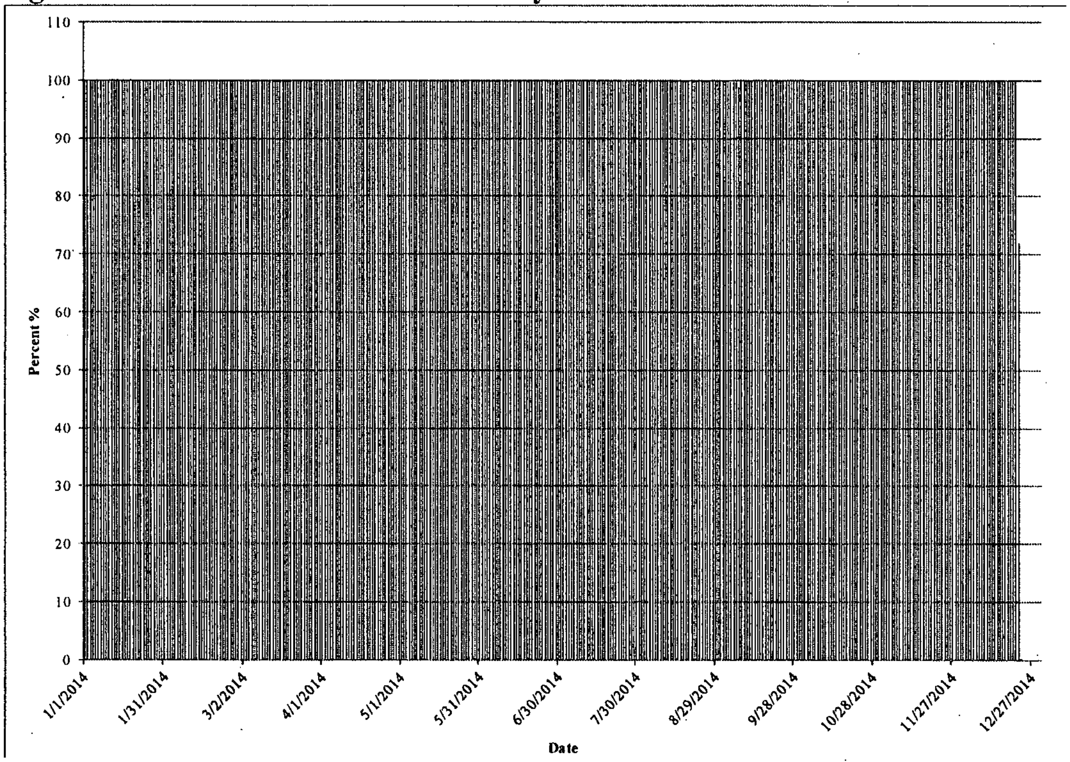
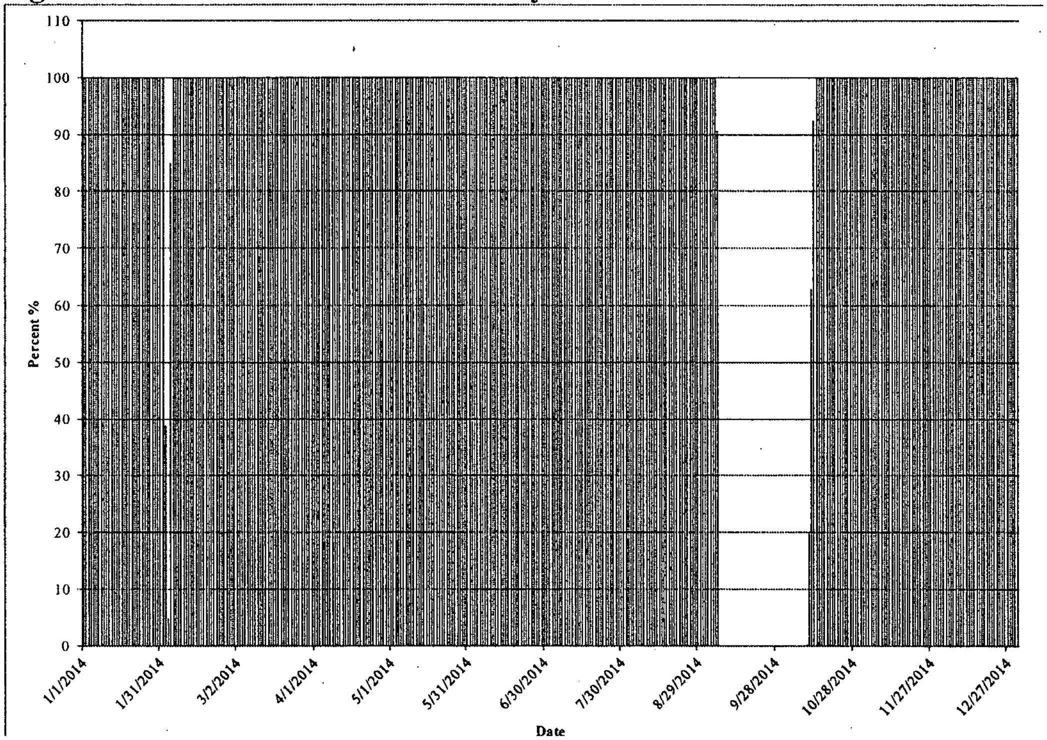


Figure 2 2014 North Anna Unit 2 Daily Power Level



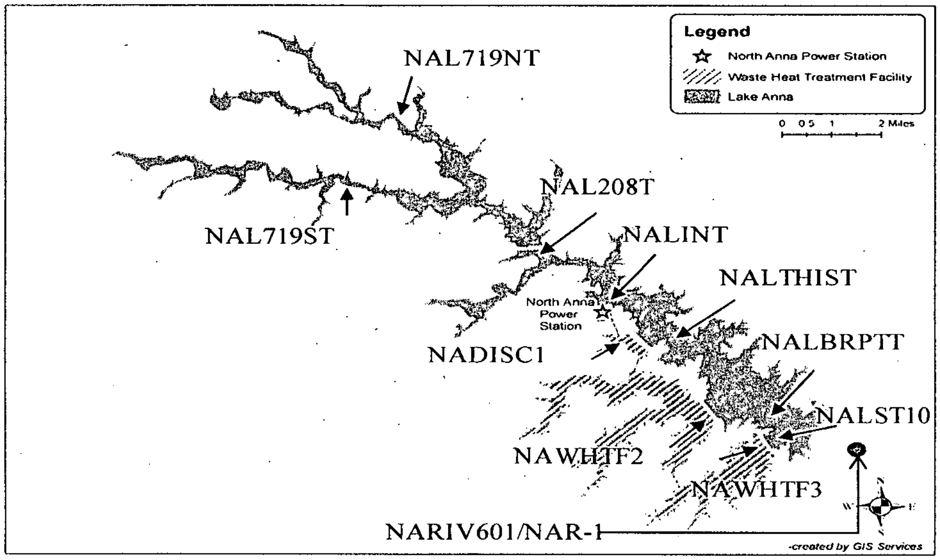
3.0 Lake Anna

3.1 Temperature

Methods

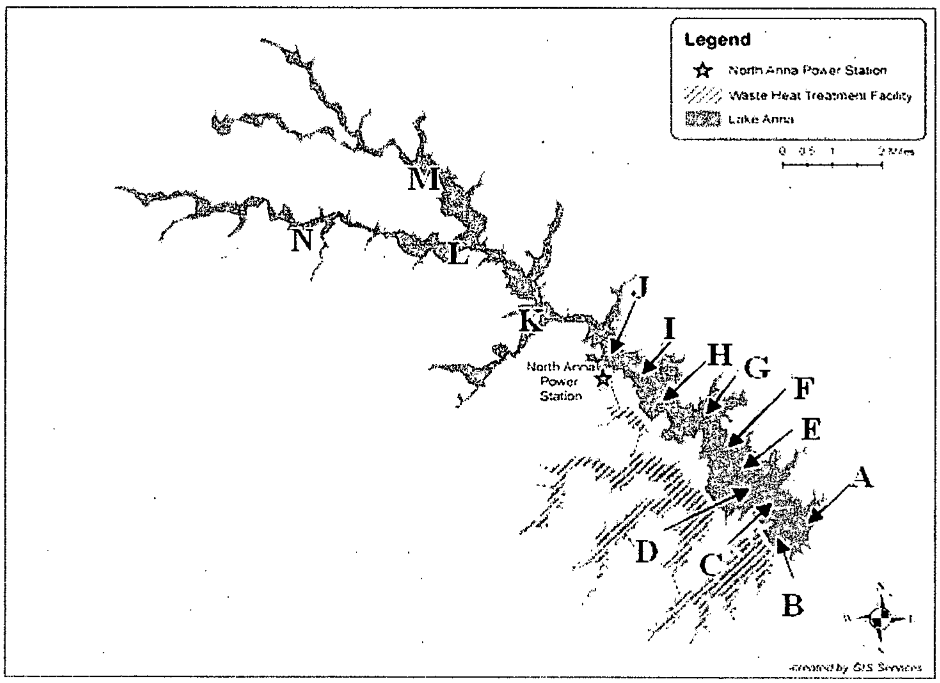
Lake, WHTF, and North Anna River water temperature data were collected using continuous monitors (fixed temperature recorders) and instantaneous temperature field surveys. Continuous temperature was measured with Solinst Levelogger (±0.1°C) temperature recorders which measured and recorded the water temperature at one hour intervals. Temperature recorders were placed at a depth of one meter at seven stations in the lake, three stations in the WHTF and one station in the river (Figure 3). The instrument at NALST10 was located at a depth of three meters to account for the turbulence associated with water discharges from the WHTF to the lake.

Figure 3 Approximate location of temperature recorders in Lake Anna, WHTF and the North Anna River



Instantaneous temperature was measured using a Hydrolab MS5 data sonde (± 0.1°C). Instantaneous temperature was measured at one meter intervals, from the surface to the bottom, at each of 14 stations in Lake Anna (Figure 4).

Figure 4 Approximate location of thermal plume sampling stations on Lake Anna



Results and Discussion

The maximum hourly temperature recorded in the WHTF in 2014 by continuous monitors was 37.6°C in July at station NADISC1 which is located at the end of the discharge canal (Table 1). The minimum hourly temperature recorded in the WHTF in 2014 was 8.2°C in January at Station NAWHTF3 which is located near the dike in the third lagoon. The maximum and minimum temperatures in the WHTF for 2014 are in the range of previously reported maximum and minimum temperatures for the WHTF.

The maximum hourly temperature recorded in the lake in 2014 by continuous temperature monitors was 31.6°C in July at station NAL719ST. The minimum hourly temperature recorded in the lake in 2014 was 1.9°C in January at NAL208T. Temperatures recorded in the lake, WHTF and river were within the range of previously reported maximum and minimum lake temperatures.

Table 1 Summary of fixed temperature recorder data during 2014 (January –May). All results are calculated from hourly temperatures (C).

January

	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
Max Temp	6.1	5.9	7.5	8.4	9.1	11.0	11.8	21.7	16.7	13.7	10.9
Mean Temp	3.9	3.8	4.8	6.1	6.7	8.6	9.7	19.6	13.8	11.2	8.1
Min Temp	2.8	2.5	1.9	3.1	3.8	5.6	7.0	17.0	10.7	8.2	5.5
Hours	744	744	744	744	744	744	744	744	743	744	743

February

	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
Max Temp	6.6	6.6	6.2	6.8	7.8	9.9	10.7	20.5	16.4	13.3	9.4
Mean Temp	4.2	4.2	3.6	5.0	5.7	7.7	8.8	18.3	13.1	10.7	7.3
Min Temp	2.7	2.5	2.1	3.5	4.5	6.3	6.9	12.8	10.4	8.7	5.7
Hours	672	672	672	672	672	672	672	672	672	672	672

March

	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
Max Temp	9.8	9.6	9.1	9.6	10.4	11.9	13.1	22.4	18.4	15.3	11.6
Mean Temp	7.0	6.9	6.7	7.6	8.2	10.0	10.8	20.5	15.2	12.9	9.6
Min Temp	4.7	4.6	4.4	5.8	6.1	8.0	8.9	18.9	11.8	10.5	7.4
Hours	744	744	744	744	744	744	744	744	744	744	744

April

	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
Max Temp	18.4	18.5	18.4	17.7	18.4	19.0	18.4	26.4	24.5	22.9	18.9
Mean Temp	15.1	15.1	14.6	14.7	15.0	15.5	15.6	24.7	21.2	19.6	15.3
Min Temp	9.0	9.0	8.2	8.9	9.5	11.5	12.4	22.0	16.5	15.3	11.3
Hours	719	719	719	719	719	717	719	719	718	719	719

May

	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
Max Temp	26.9	27.6	27.1	27.5	27.1	26.1	25.3	32.7	31.3	30.1	26.6
Mean Temp	21.7	22.1	22.1	21.7	22.0	22.0	21.5	29.1	26.9	25.6	21.6
Min Temp	12.2	12.3	15.6	15.5	16.2	17.0	17.9	24.5	22.2	20.5	16.0
Hours	744	744	744	744	744	744	744	744	744	744	744

Table 2 Summary of fixed temperature recorder data during 2014 (June-December). All results are calculated from hourly temperatures (C).

June

	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
Max Temp	30.8	31.1	30.8	30.5	30.6	30.4	29.8	37.5	35.1	33.9	31.1
Mean Temp	27.8	27.8	27.7	27.4	27.7	27.6	27.2	34.9	32.4	31.1	27.5
Min Temp	23.5	23.8	23.6	23.4	23.6	24.0	23.7	31.5	28.4	27.7	23.5
Hours	720	720	720	720	720	720	720	720	720	720	720

July

	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
Max Temp	31.6	31.4	31.3	30.3	30.9	31.0	30.4	37.6	35.8	33.8	31.9
Mean Temp	28.8	28.9	28.9	28.7	29.1	29.6	29.8	36.8	33.9	32.3	29.1
Min Temp	27.0	27.1	27.5	27.5	27.9	28.6	29.0	35.7	32.2	31.0	25.5
Hours	744	744	744	744	744	744	744	744	744	744	744

August

	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
Max Temp	29.2	29.2	29.8	30.5	30.4	31.1	29.9	37.0	34.9	32.9	30.9
Mean Temp	27.5	27.5	28.1	28.1	28.5	29.1	29.4	36.1	33.1	31.6	28.4
Min Temp	26.4	26.5	27.1	27.2	27.6	28.5	28.8	35.5	31.8	30.7	26.3
Hours	744	744	744	744	744	744	744	744	744	744	744

September

	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
Max Temp	30.2	30.4	30.3	30.0	30.3	30.7	30.4	37.5	35.3	33.3	30.8
Mean Temp	25.9	25.8	26.3	26.4	26.6	27.0	27.2	34.1	30.1	28.6	25.9
Min Temp	22.3	22.3	23.2	23.3	23.6	23.9	24.1	31.2	26.2	24.5	21.8
Hours	720	720	720	720	720	720	720	720	720	720	720

October

	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
Max Temp	23.6	23.6	23.9	24.3	24.1	25.0	24.4	31.5	28.1	26.6	24.8
Mean Temp	19.7	19.7	20.5	20.8	21.1	22.0	22.5	28.7	25.3	23.5	21.1
Min Temp	16.4	16.6	17.9	18.5	18.9	20.2	20.7	26.7	23.1	22.1	17.8
Hours	744	744	744	744	744	744	744	744	744	744	744

November

	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
Max Temp	16.4	16.7	18.0	18.5	18.9	20.2	21.0	27.2	23.7	22.0	18.9
Mean Temp	11.8	11.9	13.7	14.3	14.7	16.0	16.8	24.6	20.2	17.8	14.8
Min Temp	8.2	8.4	10.2	10.8	11.2	12.3	13.6	20.9	16.6	14.6	11.3
Hours	720	720	720	720	720	720	720	720	720	720	720

December

	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
Max Temp	9.4	9.9	11.3	11.5	12.1	13.6	14.2	24.7	20.6	16.2	13.9
Mean Temp	7.0	7.2	8.8	9.5	10.0	11.5	12.3	21.8	16.2	14.3	10.8
Min Temp	5.7	5.9	7.4	8.4	8.6	10.2	10.9	17.2	12.8	12.1	8.9
Hours	743	743	744	744	744	744	743	744	743	744	743

The instantaneous temperature surveys were conducted in March, May, September, and November to provide temperature data to assess seasonal thermal stratification patterns in the lake (Table 3). Results of the March survey show a maximum temperature decrease of 2.3°C from surface to bottom with very little stratification. The May survey shows a thermocline (a layer within a body of water where the temperature changes rapidly with depth) forming at the 10 to 11 meter depths at Station A up lake to Station F. Beyond that point, in the middle and upper lake, a thermocline was less pronounced as indicated by more gradual changes in temperatures from surface to bottom. The September survey shows very minimal temperature change with depth, while the November survey shows a slight decrease in temperature with decreasing depth.

Table 3 Lake Anna water temperatures for the instantaneous temperature surveys (March and May) measured (C) at one meter intervals

3/21/2014	Depth (m)	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	0	11.3	11.5	11.3	11.1	10.7	9.7	9.3	8.6	8.6	8.1	7.5	7.0	7.8	7.9
	1	11.3	11.4	11.3	11.1	10.7	9.7	9.3	8.6	8.5	8.1	7.5	6.9	7.7	7.8
	2	11.3	11.4	11.3	11.0	10.6	9.6	9.2	8.6	8.2	8.0	7.1	6.8	7.2	7.2
	3	11.1	11.4	11.2	10.9	10.4	9.5	9.1	8.5	8.1	8.0	7.0	6.8	7.1	7.1
	4	11.1	11.3	11.1	10.3	10.3	9.4	9.1	8.5	8.1	8.0	6.9	6.7	7.1	7.1
M	5	11.1	11.2	10.9	10.2	10.2	9.3	8.8	8.5	8.1	7.9	6.9	6.7	7.1	7.1
	6	11.1	11.1	10.6	10.1	10.1	9.3	8.8	8.5	8.1	7.8	6.8	6.7	7.0	7.0
	7	11.0	11.0	10.2	10.1	9.9	9.3	8.7	8.4	8.1	7.8	6.8	6.7	7.0	7.0
A	8	10.9	10.8	9.7	9.9	9.5	9.3	8.7	8.4	7.8	7.7	6.8		7.0	
	9	10.0	10.5	9.6	9.3	9.3	9.2	8.6	8.3	7.6	7.5	6.8			
R	10	9.7	10.4	9.5	9.2	9.2	9.1	8.6	8.1	7.5	7.1	6.7			
	11	9.7	10.1	9.4	9.1	9.2	8.8	8.6	8.0	7.4	6.9	6.7			
C	12	9.3	9.9	9.3	9.1	9.2	8.8	8.5	7.8	7.2	6.8	6.7			
	13	9.3	9.7	9.2	9.1	9.2	8.4	8.4	7.6	7.1	6.7	6.7			
H	14	9.3	9.3	9.1	9.1	9.1	8.4	8.2	7.6		6.7	6.7			
	15	9.3	9.3	9.1	9.0	9.1	8.4	7.9	7.5			6.7			
	16	9.3	9.3	9.1	8.9	9.0	8.4	7.7							
	17	9.2	9.3	9.0	8.9	9.0	8.3	7.6							
	18	9.2		9.0	8.9	9.0	8.4	7.6							
	19	9.1		9.1	8.9		8.4	7.7							
	20	9.0					8.4								

Warm Cool

5/8/2014	Depth	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	0	22.8	21.6	23.9	22.3	21.7	23.2	22.2	21.5	23.4	21.9	21.7	22.7	22.9	21.6
	1	21.0	20.9	20.0	20.3	19.7	21.0	21.2	20.5	20.7	20.7	21.4	19.8	19.7	20.3
	2	20.6	20.4	19.9	19.7	19.6	20.4	20.3	19.9	20.0	20.1	20.1	19.2	18.8	19.5
	3	20.4	20.2	19.7	19.6	19.5	20.1	20.3	19.4	19.6	20.0	19.8	18.8	17.9	17.3
	4	20.3	20.0	19.6	19.4	19.4	19.9	20.0	19.4	19.2	19.7	18.5	17.2	16.9	16.5
	5	20.2	18.9	19.5	19.4	19.4	19.8	19.8	18.8	19.1	19.6	18.4	16.7	16.3	16.0
	6	19.9	17.5	19.5	19.3	19.3	19.6	19.7	18.4	18.8	18.9	16.5	16.4	14.9	15.5
	7	19.4	17.1	19.2	19.2	19.1	19.3	18.1	17.7	17.4	17.5	16.3	16.0	13.4	15.6
M	8	18.9	16.5	19.1	19.1	19.0	18.4	17.1	17.2	16.9	16.8	15.8		13.2	
	9	18.4	16.1	18.9	18.3	18.1	17.6	16.5	16.6	16.8	15.6	14.4			
A	10	18.1	15.7	17.7	16.7	17.2	16.5	16.3	16.0	15.8	15.1	14.1			
	11	16.1	15.5	16.3	16.3	16.3	15.9	16.0	14.7	14.5	14.6	13.7			
Y	12	15.7	15.1	15.9	15.6	15.7	15.4	15.6	14.6	14.3	14.4	13.5			
	13	15.3	15.0	15.8	15.3	15.2	15.2	15.3	14.3	14.2	14.2	13.5			
	14	14.9	15.0	15.7	15.0	15.0	14.9	15.1	14.2		14.2	13.5			
	15	14.7	15.0	15.5	14.9	14.9	14.7	14.4	14.1			14.1			
	16	14.6	15.0	14.8	14.7	14.8	14.6	14.4							
	17	14.3		14.7	14.6	14.7	14.6	14.3							
	18	13.7		14.6	14.3	14.5	14.6	14.3							
	19	13.6		14.3	13.7		14.6	14.3							
	20	13.8					14.6								

Warm Cool

Table 4 Lake Anna water temperatures from the instantaneous temperature surveys (September and November) measured in (C) one meter intervals

9/10/2014	Depth	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	0	28.5	28.7	28.5	28.2	28.1	27.7	27.6	27.5	27.4	27.3	27.3	27.0	27.1	27.0
	1	28.5	28.6	28.5	28.2	28.1	27.7	27.6	27.5	27.3	27.3	27.3	27.0	27.0	26.7
S	2	28.5	28.6	28.4	28.1	28.1	27.7	27.5	27.4	27.3	27.3	27.2	26.9	26.9	26.7
	3	28.5	28.6	28.3	28.0	28.0	27.6	27.5	27.4	27.3	27.3	27.2	26.9	26.9	26.6
e	4	28.5	28.3	28.2	28.0	28.0	27.6	27.5	27.4	27.3	27.3	27.2	26.9	26.9	26.5
	5	28.5	28.2	28.2	27.9	28.0	27.6	27.5	27.3	27.3	27.3	27.2	26.9	26.8	26.3
p	6	28.5	28.1	28.0	27.8	27.9	27.6	27.5	27.3	27.3	27.3	27.1	26.9	26.8	26.1
	7	28.3	28.1	28.0	27.8	27.8	27.6	27.5	27.3	27.3	27.3	27.1	26.9	26.8	26.0
t	8	28.2	27.8	28.0	27.8	27.8	27.6	27.4	27.3	27.3	27.3	27.0	26.9	26.8	
	9	27.9	27.5	27.8	27.8	27.7	27.6	27.4	27.2	27.3	27.2	27.0	26.8		
e	10	27.7	27.5	27.6	27.7	27.7	27.5	27.4	27.2	27.2	27.2	27.0	26.8		
	11	27.6	26.9	27.3	27.5	27.7	27.4	27.4	27.2	27.2	27.1	26.9			
m	12	26.9	26.8	27.2	27.4	27.3	27.1	27.3	27.1	27.0	26.9	26.8			
	13	26.9	26.6	26.5	27.1	27.2	26.9	27.2	27.0	27.0	26.4	26.4			
b	14	26.7	26.6	26.4	26.8	26.6	26.6	27.1	26.7		26.4	26.1			
	15	26.5	26.6	26.2	26.4	26.4	26.4	26.5	26.5			25.9			
	16	26.5	26.6	25.5	26.3	26.3	26.1	26.0				25.8			
e	17	26.1		23.6	26.1	26.0	26.0	25.8							
	18	25.4		21.4	25.9	26.1	25.8	25.8							
r	19	23.5		17.4	24.7		25.6	25.7							
	20	20.6					21.4								

Warm Cool

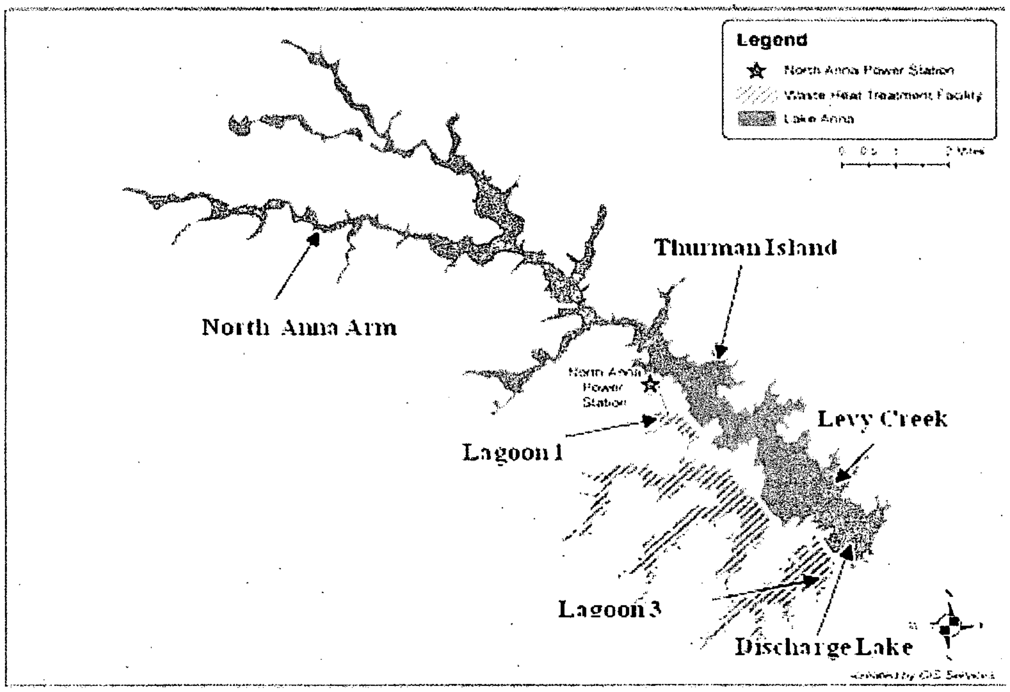
11/12/2014	Depth	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	0	18.7	18.6	18.5	18.5	18.5	18.3	18.0	17.8	17.4	17.3	16.6	15.2	14.8	14.9
	1	18.7	18.6	18.5	18.5	18.5	18.3	17.9	17.8	17.4	17.3	16.5	15.2	14.7	14.9
	2	18.5	18.4	18.5	18.3	18.3	18.0	17.9	17.1	17.3	17.2	15.8	15.2	14.1	14.7
N	3	18.5	18.4	18.3	17.9	18.1	18.0	17.7	17.1	17.3	16.7	15.8	15.1	13.6	13.7
	4	18.3	18.2	17.8	17.7	17.7	18.0	17.7	16.5	17.3	16.7	15.5	14.5	13.5	12.8
o	5	18.3	18.1	17.3	17.3	17.3	17.9	17.7	16.1	17.3	16.6	14.9	14.3	13.1	12.6
	6	18.3	17.8	17.2	17.1	17.2	17.9	17.5	16.0	16.1	16.2	14.7	14.2	12.7	12.6
v	7	18.3	17.6	17.1	17.1	17.1	17.5	17.5	15.9	15.9	15.9	14.4	13.9	12.7	12.5
	8	17.9	17.6	17.0	17.0	17.1	17.1	17.4	15.8	15.9	15.2	14.4		12.7	
e	9	17.2	17.4	17.0	17.0	17.0	17.0	16.9	15.7	15.9	15.1	14.2			
	10	17.0	17.5	17.0	17.0	17.0	16.8	16.5	15.7	15.9	14.9	14.2			
m	11	16.9	17.4	16.9	17.0	17.0	16.4	16.5	15.5	15.5	14.8	14.2			
	12	16.9	17.5	16.9	17.0	17.0	16.3	16.5	15.3	14.9	14.6	14.2			
b	13	16.9	17.5	16.9	16.9	16.8	16.0	16.1	15.2	14.8	14.6	14.2			
	14	16.9	17.5	16.9	16.7	16.7	16.0	15.7	15.0		14.6				
e	15	16.9	17.5	16.9	16.7	16.7	15.9	15.7	15.0						
	16	16.9	17.5	16.9	16.6	16.7	15.7	15.8							
	17	16.9		16.8	16.6	16.7	15.7	15.7							
r	18	16.9		16.8	16.6	16.7	15.7	15.5							
	19	16.9		16.7	16.6		15.7								
	20	16.9					15.7								

Warm Cool

Methods

The monitoring of fish abundance and species composition for Lake Anna and the WHTF continued in 2014 using the same sampling methods as previous years, gill netting and boat electrofishing. Gill netting was used to capture fishes which normally inhabit the deeper strata of the lake, or exhibit a movement to and from the shoreline within a 24-hour period. Similar to previous years, gill net surveys for 2014 were conducted seasonally (March, May, August, and November) at each of six stations (Figure 5). Gill nets were set near littoral (near the shoreline) drop-off areas and left overnight. Standard physicochemical measurements including surface water temperature (°C), dissolved oxygen (mg/l), pH and conductivity (uS/cm) were recorded at the time of each sample collection. Fish collected by gill netting were returned to the laboratory for processing. Length (mm) and weight (g) were recorded for each fish. The fish for each sample were sorted by species and enumerated. Catch per unit effort (CPUE) was calculated as the number of fish per net night. CPUE for 2014 was compared to historical average CPUE using a one sample t-test with a 95% confidence interval (CI).

Figure 5 Location of gill netting stations on Lake Anna and WHTF



Results and Discussion

Standard physicochemical measurements recorded during gill net surveys are shown in Table 5. The data demonstrate expected seasonal changes in temperature and dissolved oxygen, while conductivity and pH were relatively stable. The data are consistent with historical trends and indicate that these water quality parameters in Lake Anna and the WHTF are within the values to support a healthy fishery.

Table 5 Surface water temperature (C), conductivity (uS/cm), ph (su) and dissolved oxygen (mg/L) recorded at time of gill net sampling during 2014

March					May				
Station	Temperature	Conductivity	pH	Dissolved Oxygen	Station	Temperature	Conductivity	pH	Dissolved Oxygen
DIKE3 DISCHARGE LAKE	10.70	53	6.6	10.70	DIKE3 DISCHARGE LAKE	24.50	60	7.0	7.00
LAGOON 1 WHTF	20.20	59	6.6	*	LAGOON 1 WHTF	29.00	58	7.3	8.15
LAGOON 3 WHTF	13.19	59	6.7	10.60	LAGOON 3 WHTF	27.09	57	7.4	7.90
LEVY CREEK	9.90	52	6.5	11.00	LEVY CREEK	22.43	58	7.1	7.30
NORTH ANNA ARM GN	7.97	58	6.5	14.00	NORTH ANNA ARM GN	26.11	53	7.8	9.80
THURMAN ISLAND GN	9.18	52	6.2	12.30	THURMAN ISLAND GN	27.20	60	7.3	8.44
August					**November**				
Station	Temperature	Conductivity	pH	Dissolved Oxygen	Station	Temperature	Conductivity	pH	Dissolved Oxygen
DIKE3 DISCHARGE LAKE	29.70	55	7.2	5.40	DIKE3 DISCHARGE LAKE	15.90	55	6.9	8.75
LAGOON 1 WHTF	36.20	56	7.4	6.56	LAGOON 1 WHTF	23.29	54	7.0	8.71
LAGOON 3 WHTF	32.00	54	7.1	6.70	LAGOON 3 WHTF	17.77	54	7.1	8.45
LEVY CREEK	29.40	54	7.5	6.80	LEVY CREEK	14.60	55	6.8	9.00
NORTH ANNA ARM GN	27.90	59	8.1	9.15	NORTH ANNA ARM GN	9.80	63	7.2	10.60
THURMAN ISLAND GN	28.63	54	7.7	6.99	THURMAN ISLAND GN	13.75	54	6.9	9.20

Nineteen species of fish representing seven families were collected in Lake Anna and the WHTF by quarterly gill netting in 2014 (Table 6). Table 7 summarizes the gill net catch data by species and season for all lake stations in 2014. The numerically dominant species collected in the lake were Gizzard Shad *Dorosoma cepedianum*, White Perch *Morone americana*, Threadfin Shad *Dorosoma petenense,* Channel Catfish *Ictalurus punctatus*, and Striped Bass *Morone saxatilis*. These five species represented 75% of the gill net catch by number.

Table 6 Fishes collected in Lake Anna and the WHTF by gill netting during 2014

FAMILY	SPECIES	LAKE	WHTF
Catostomidae	*Carpiodes cyprinus*		x
	Catostomus commersonii	x	
	Moxostoma macrolepidotum	x	
Centrarchidae	*Chaenobryttus gulosus*	x	
	Lepomis macrochirus	x	
	Lepomis microlophus	x	x
	Micropterus salmoides	x	x
	Pomoxis nigromaculatus	x	
Clupeidae	*Alosa aestivalis*		x
	Dorosoma cepedianum	x	x
	Dorosoma petenense	x	
Cyprinidae	*Cyprinus carpio*	x	x
Ictaluridae	*Ameiurus catus*	x	x
	Ictalurus furcatus	x	x
	Ictalurus punctatus	x	x
Moronidae	*Morone americana*	x	x
	Morone saxatilis	x	x
Percidae	*Perca flavescens*	x	
	Sander vitreum x canadense	x	x

Table 7 Gill net summary for pooled lake stations during 2014; Number and Weight (g)

	FEBRUARY		MAY		AUGUST		NOVEMBER		TOTALS		% OF TOTAL	
SPECIES	NUMBER	WEIGHT	NUMBER	WEIGHT	NUMBER	WEIGHT	NUMBER	WEIGHT	NUMBER	WEIGHT	NUMBER	WEIGHT
Dorosoma cepedianum	23	4587.0	12	2938.0	89	12736.0	43	2700.0	167	22961.0	18%	8%
Morone americana	47	4275.0	29	1991.0	22	1570.0	64	1710.0	162	9546.0	17%	3%
Dorosoma petenense					85	724.0	66	506.0	151	1230.0	16%	0%
Ictalurus punctatus	17	8484.0	44	11748.0	18	10446.0	35	15452.0	114	46130.0	12%	16%
Morone saxatilis	24	27797.0	49	38275.0	12	11607.0	15	20190.0	100	97869.0	11%	34%
Pomoxis nigromaculatus	25	2403.0	9	1043.0	54	3926.0	9	2411.0	97	9783.0	10%	3%
Ameiurus catus	41	4795.0	20	4236.0	4	274.0	7	1224.0	72	10529.0	8%	4%
Cyprinus carpio	6	14106.0	5	18073.0	7	20629.0	1	3421.0	19	56229.0	2%	20%
Micropterus salmoides	4	5332.0	4	3541.0	6	2471.0	5	3035.0	19	14379.0	2%	5%
Moxostoma macrolepidotum			1	289.0	2	1190.0	6	6104.0	9	7583.0	1%	3%
Sander vitreum x canadense							8	8061.0	8	8061.0	1%	3%
Lepomis microlophus	1	342.0	2	513.0	1	204.0			4	1059.0	0%	0%
Lepomis macrochirus					1	6.0	2	11.0	3	17.0	0%	0%
Catostomus commersonii							2	1670.0	2	1670.0	0%	1%
Perca flavescens	1	9.0	1	17.0					2	26.0	0%	0%
Chaenobryttus gulosus					1	8.0			1	8.0	0%	0%
Ictalurus furcatus							1	1108.0	1	1108.0	0%	0%
Totals	**189**	**72,130**	**176**	**82,664**	**302**	**65,791**	**264**	**67,603**	**931**	**288,188**	**100%**	**100%**

The numerically dominant species collected by gill netting in the WHTF in 2014 were Channel Catfish, followed by Gizzard Shad, White Perch, Striped Bass and Largemouth Bass *Micropterus salmoides* (Table 8). Together these species represented 86% of the number of fish collected.

Table 8 Gill net summary for pooled WHTF stations during 2014; Number and Weight (g)

	FEBRUARY		MAY		AUGUST		NOVEMBER		TOTALS		% OF TOTAL	
SPECIES	NUMBER	WEIGHT	NUMBER	WEIGHT	NUMBER	WEIGHT	NUMBER	WEIGHT	NUMBER	WEIGHT	NUMBER	WEIGHT
Ictalurus punctatus	19	12758.0	66	21069.0	7	1247.0	13	5435.0	105	40509.0	33%	24%
Dorosoma cepedianum	45	17874.0	34	12929.0	9	2825.0	9	4409.0	97	38037.0	31%	22%
Morone americana	6	1528.0	16	1005.0			11	2234.0	33	4767.0	10%	3%
Morone saxatilis	20	23728.0	1	781.0			1	885.0	22	25394.0	7%	15%
Micropterus salmoides	3	1459.0	3	1211.0	5	1001.0	5	3551.0	16	7222.0	5%	4%
Cyprinus carpio	4	8757.0	9	26097.0			2	5090.0	15	39944.0	5%	23%
Ameiurus catus	2	270.0	9	1289.0			2	331.0	13	1890.0	4%	1%
Lepomis microlophus	3	400.0	1	148.0	5	642.0	1	172.0	10	1362.0	3%	1%
Alosa aestivalis	2	29.0					1		3	29.0	1%	0%
Carpiodes cyprinus							1	2001.0	1	2001.0	0%	1%
Ictalurus furcatus							1	8845.0	1	8845.0	0%	5%
Sander vitreum x canadense							1	860.0	1	860.0	0%	1%
Totals	**104**	**66803**	**139**	**64529**	**26**	**5715**	**48**	**33813**	**317**	**170,860**	**100%**	**100%**

The 2014 CPUE (#/net night) for the top 5 gill net species for the lake and WHTF were compared to their 1981-2013 historical averages and are presented in Table 9.

Table 9 CPUE for the top 5 species, 1981-2013 averages and p-values (1 sample T-test; 95%CI) for gill netting samples in the Lake and WHTF

Lake			
Species	2014 CPUE-N	81-'13 Average CPUE-N	CPUE_N (p-value)
Dorosoma cepedianum	10.44	10.16	0.353
Morone americana	10.13	4.91	0.000
Dorosoma petenense	9.44	3.28	0.000
Ictalurus punctatus	7.13	3.87	0.000
Morone saxatilis	6.25	3.06	0.000

WHTF			
Species	2014 CPUE-N	81-'13 Average CPUE-N	CPUE_N (p-value)
Ictalurus punctatus	13.13	10.39	0.001
Dorosoma cepedianum	12.13	9.03	0.001
Morone americana	4.13	3.77	0.198
Morone saxatilis	2.75	1.07	1.000
Micropterus salmoides	2.00	4.08	0.000

In the lake, White Perch, Threadfin Shad, Channel Catfish and Striped Bass had a CPUE that was significantly higher than the 1981-2013 average. Gizzard Shad CPUE for 2014 was higher than the historical average but the difference was not significant.

In the WHTF, Channel Catfish, Gizzard Shad, and White Perch had a CPUE that was significantly higher than the historical average. Striped Bass CPUE was higher than the historical average but the difference was not significant. Largemouth Bass had a CPUE that was significantly lower than the historical average. The CPUE for the 2014 numerically dominant gill net species in the lake and WHTF are displayed graphically from 1981-2014 in Figure 6 and Figure 7.

Figure 6 CPUE for the 2014 numerically dominant gill net species for the lake 1981-2014

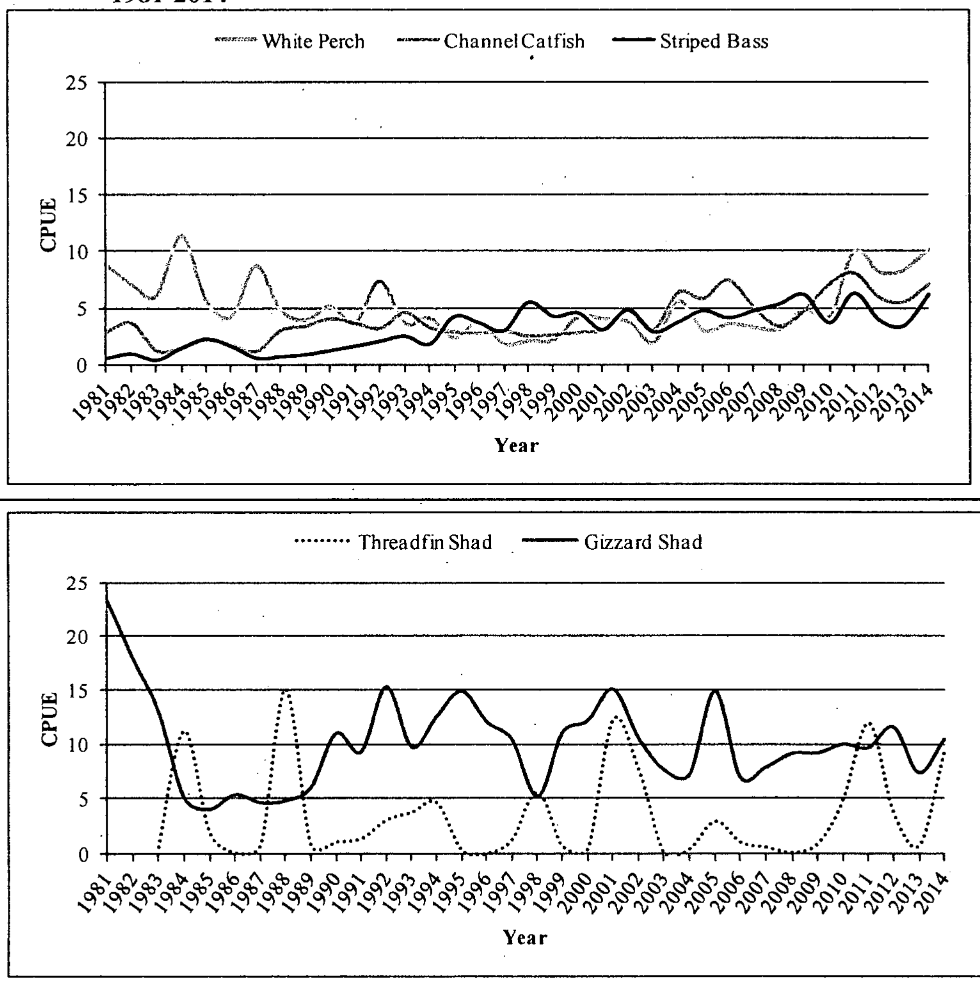
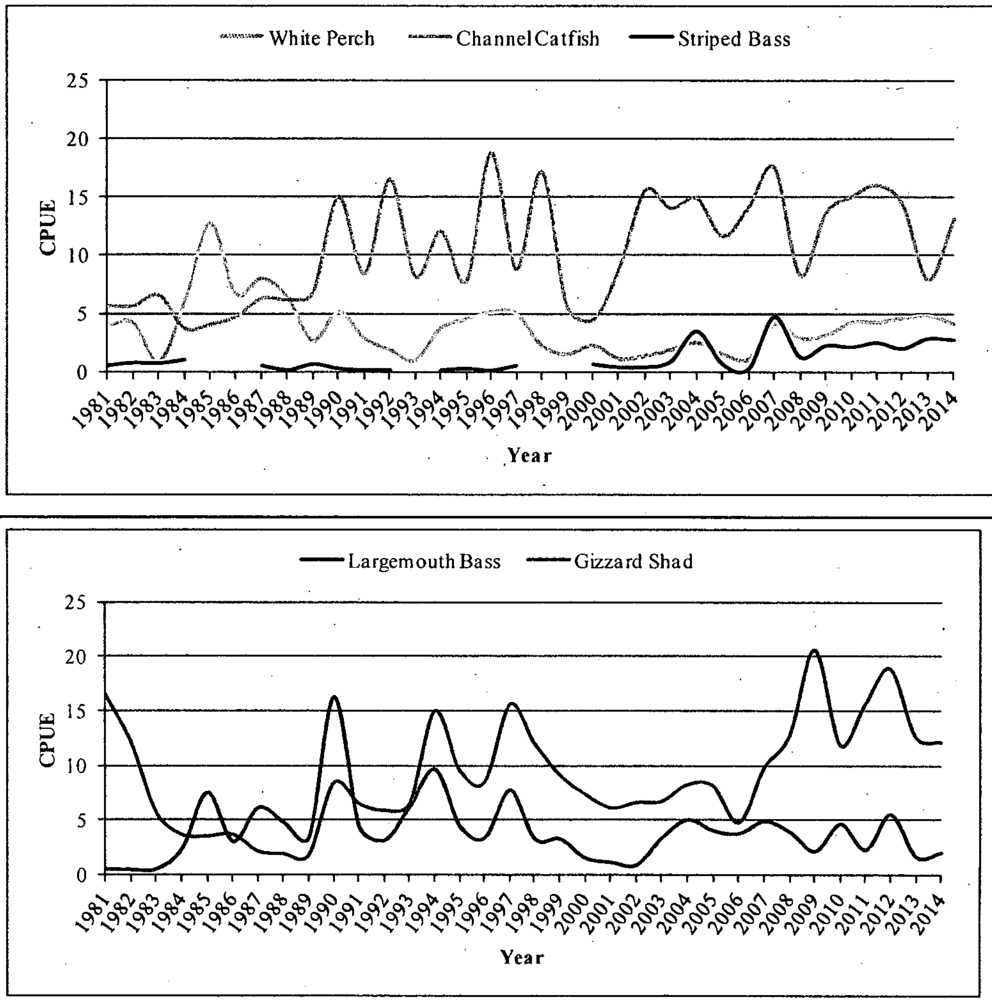


Figure 7 CPUE for the 2014 numerically dominant gill net species for the WHTF 1981-2014



Over the last 33 years, Striped Bass and Channel Catfish catch rates have been slowly increasing in the lake. White Perch catch rates were declining from 1981-1994 but have been increasing ever since (Figure 6). Striped Bass recruitment is driven by the DGIF stocking program while White Perch and Channel Catfish reproduce naturally in the lake.

Threadfin Shad and Gizzard Shad catches at the lake stations show high annual variability, yet have a consistent presence in lake gill net samples (Figure 7). Shad are pelagic (open water) schooling species. Large schools of shad can inflate the CPUE causing large fluctuations in catches among years. In the WHTF, Channel Catfish have shown a highly variable catch rate over time. White Perch and Striped Bass catches appear to be slowly increasing over the last few years (Figure 7). Gizzard Shad gill net catch rates in the WHTF are highly variable, as in the lake, and appear to be slowly increasing over time (Figure 7). Largemouth Bass have shown a consistent presence in WHTF gill net samples and catch rates in the WHTF show some variability with an average catch rate of 4 fish per net night.

Channel Catfish, Striped Bass, White Perch, Largemouth Bass, Threadfin Shad and Gizzard Shad have commonly ranked high in the gill net catches in the lake and WHTF. Their consistent presences in the gill net samples indicate a stable species composition in the lake and WHTF.

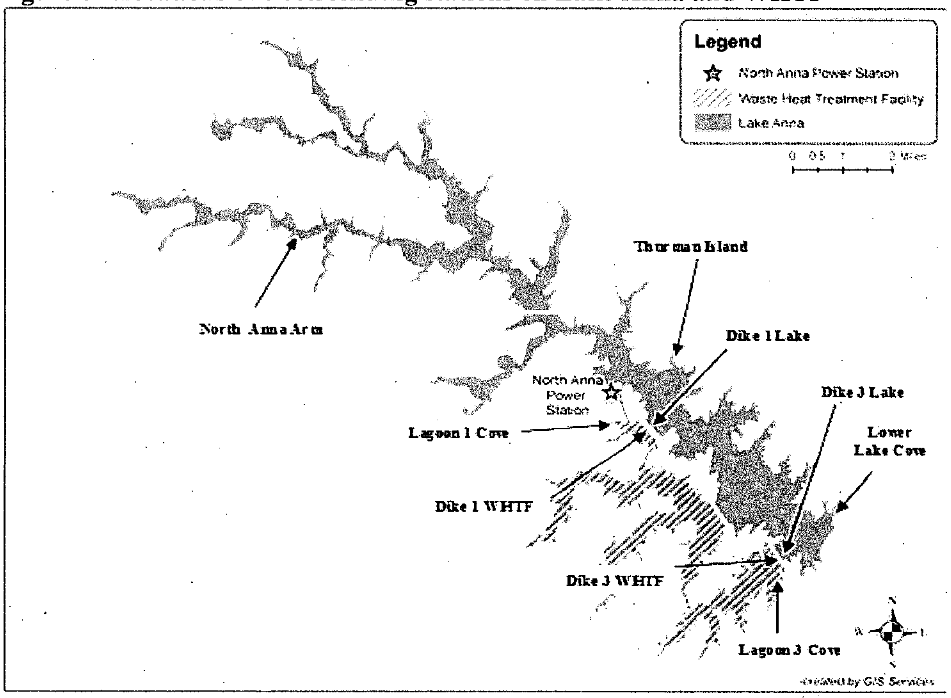
3.3 Fish Population Studies - Electrofishing

Methods

Boat electrofishing was used in 2014 to evaluate the assemblage and abundance of fish populations which normally occupy the shoreline habitat. Sampling was conducted in February, May, August, and November at each station (Figure 8). Each station is 100 meters in length and is sampled by electrofishing for approximately 10 minutes. Sampling stations normally include a brush pile except for the dike stations which are comprised of uniform rip-rap. It has been observed that the brush piles have degraded at some of the electrofishing stations including Lagoon 1 Cove, North Anna Arm and Lower Lake Cove. The reduction of brush piles has altered the habitat available for fish which may affect electrofishing results. Standard physicochemical measurements of surface water temperature (°C), dissolved oxygen (mg/l), pH and conductivity (μmhos) were recorded at the time of each sample collection.

All fish collected were either returned to the laboratory for processing or released in the field, i.e., larger game fish were measured, weighed, and released in the field. In the laboratory, fish were sorted by species and up to 25 individuals per species from each station were measured for total length (mm) and weighed (g). The remaining fish (per species) were enumerated and bulk weighed. CPUE was calculated as the number of fish collected per hour of electrofishing. CPUE for 2014 was compared to historical averages of CPUE using a one sample t-test with a 95% CI.

Figure 8 Locations of electrofishing stations on Lake Anna and WHTF



Results and Discussion

Physicochemical measurements recorded at each station during electrofishing surveys are presented in Table 10. Seasonal changes in water temperatures and dissolved oxygen were noticeable and expected while conductivity and pH remained relatively stable. The data are consistent with historical trends and indicate that these water quality parameters in Lake Anna and the WHTF are within the values to support a healthy fishery.

Table 10 Surface water temperature (C), conductivity (uS/cm), pH (su) and dissolved oxygen (mg/l) recorded at time of electrofishing sampling during 2014. * denotes missing data

Electrofishing Stations	Temperature	Conductivity	pH	Dissolved Oxygen
March				
DIKE 1 LAKE	10.70	53	6.6	12.2
DIKE 3 LAKE	10.35	53	6.6	11.1
LAGOON 1 WHTF COVE	19.00	59	6.6	*
LAGOON 1 WHTF DIKE	20.10	60	6.7	*
LAGOON 3 WHTF COVE	13.10	59	6.7	*
LAGOON 3 WHTF DIKE	12.77	58	6.7	10.6
LOWER LAKE COVE	11.20	52	6.5	11.2
NORTH ANNA ARM EF	10.60	59	6.7	14.0
THURMAN ISLAND EF	9.40	52	6.5	12.3
May				
DIKE 1 LAKE	25.74	60	7.2	8.5
DIKE 3 LAKE	24.10	60	7.0	7.2
LAGOON 1 WHTF COVE	29.80	58	7.4	8.4
LAGOON 1 WHTF DIKE	29.40	60	7.2	8.0
LAGOON 3 WHTF COVE	26.20	59	7.2	7.6
LAGOON 3 WHTF DIKE	26.00	59	7.3	7.6
LOWER LAKE COVE	22.70	58	7.1	7.7
NORTH ANNA ARM EF	28.70	51	7.8	9.7
THURMAN ISLAND EF	28.70	51	7.8	9.7
August				
DIKE 1 LAKE	28.60	55	7.5	7.0
DIKE 3 LAKE	29.80	55	7.0	5.5
LAGOON 1 WHTF COVE	35.38	55	7.3	7.3
LAGOON 1 WHTF DIKE	36.20	55	7.2	6.6
LAGOON 3 WHTF COVE	31.80	54	7.2	7.6
LAGOON 3 WHTF DIKE	31.80	54	7.3	7.2
LOWER LAKE COVE	30.30	54	7.5	7.8
NORTH ANNA ARM EF	27.30	59	7.4	8.5
THURMAN ISLAND EF	29.00	54	7.8	7.8
November				
DIKE 1 LAKE	12.60	55	6.4	9.5
DIKE 3 LAKE	14.80	55	6.8	9.0
LAGOON 1 WHTF COVE	21.22	56	6.9	8.8
LAGOON 1 WHTF DIKE	22.83	56	6.9	8.9
LAGOON 3 WHTF COVE	16.40	55	7.0	8.7
LAGOON 3 WHTF DIKE	16.68	55	7.0	8.7
LOWER LAKE COVE	14.50	55	6.9	9.5
NORTH ANNA ARM EF	8.90	63	7.0	10.5
THURMAN ISLAND EF	11.99	54	6.8	9.4

Twenty-three species of fish representing 5 families were collected by electrofishing in the lake and WHTF in 2014 (Table 11).

Table 11 Fishes collected in Lake Anna and the WHTF by electrofishing during 2014

FAMILY	SPECIES	LAKE	WHTF
Centrarchidae	*Chaenobryttus gulosus*	x	x
	Lepomis auritus	x	x
	Lepomis cyanellus	x	x
	Lepomis gibbosus	x	
	Lepomis macrochirus	x	x
	Lepomis microlophus	x	x
	Micropterus salmoides	x	x
	Pomoxis nigromaculatus	x	
Clupeidae	*Alosa aestivalis*	x	
	Dorosoma cepedianum	x	x
	Dorosoma petenense	x	
Cyprinidae	*Cyprinus carpio*		x
	Notemigonus crysoleucas	x	
	Notropis rubellus	x	
	Fundulus diaphanus	x	
Ictaluridae	*Ameiurus catus*	x	x
	Ameiurus natalis	x	x
	Ameiurus nebulosus	x	x
	Ictalurus punctatus	x	x
Moronidae	*Morone americana*	x	
	Morone saxatilis	x	
	Etheostoma olmstedi	x	
	Perca flavescens	x	

Table 12 presents the electrofishing catch data by species and season at lake stations in 2014. The numerically dominant species collected in the lake were Bluegill *Lepomis macrochirus*, Threadfin Shad, Green Sunfish *Lepomis cyanellus*, Redear Sunfish *Lepomis* *microlophus* and Redbreast Sunfish *Lepomis auritus*. These 5 species represented 90% of the electrofishing catch by number.

Table 12 Electrofishing summary for pooled lake stations during 2014; Number and Weight (g)

	FEBRUARY		MAY		AUGUST		NOVEMBER		TOTALS		% OF TOTAL	
SPECIES	NUMBER	WEIGHT	NUMBER	WEIGHT	NUMBER	WEIGHT	NUMBER	WEIGHT	NUMBER	WEIGHT	NUMBER	WEIGHT
Lepomis macrochirus	698	9620.5	171	2134.9	163	1698.3	1153	16278.5	2185	29732	68%	44%
Dorosoma petenense					49	201.2	265	943.0	314	1144	10%	2%
Lepomis cyanellus	67	668.1	19	358.4	19	292.0	74	1075.0	179	2394	6%	4%
Lepomis microlophus	44	885.4	8	283.2	10	232.1	45	713.0	107	2114	3%	3%
Lepomis auritus	53	1865.4	2	37.7	11	222.0	34	1701.0	100	3826	3%	6%
Micropterus salmoides	20	6027.1	16	5348.3	21	323.4	33	5941.0	90	17640	3%	26%
Chaenobryttus gulosus	17	628.6	3	102.7	7	179.8	59	1709.0	86	2620	3%	4%
Dorosoma cepedianum	42	487.6	6	1682.0	2	255.0			50	2425	2%	4%
Perca flavescens			5	42.5	7	109.1	23	608	35	760	1%	1%
Morone americana	6	315	1	126	21	289.0	5.0	188.0	33	918	1%	1%
Pomoxis nigromaculatus			7	1506	3	455			10	1961	0%	3%
Alosa aestivalis							7	33.0	7	33	0%	0%
Ictalurus punctatus			2	359.7	4	43.6			6	403	0%	1%
Ameiurus catus					4	132.5			4	133	0%	0%
Lepomis gibbosus							4	133.0	4	133	0%	0%
Ameiurus natalis	1	59.2					2	201.0	3	260	0%	0%
Fundulus diaphanus	3	5.5							3	6	0%	0%
Notropis rubellus					3	8.8			3	9	0%	0%
Ameiurus nebulosus			1	279.0					1	279	0%	0%
Etheostoma olmstedi							1	1.0	1	1	0%	0%
Morone saxatilis							1.0	570.0	1	570	0%	1%
Notemigonus crysoleucas	1	3.2							1	3	0%	0%
Totals	**952**	**20,566**	**241**	**12,260**	**324**	**4,442**	**1,706**	**30,095**	**3,223**	**67,362**	**100%**	**100%**

The 2013 CPUE for the numerically dominant electrofishing species for the lake and WHTF were compared to their 1981-2013 historical averages in Table 13.

Table 13 CPUE (#/hr) for the top 5 species, 1981-2013 averages and p-values (1 sample T-test; 95% CI) for electrofishing samples in the Lake and WHTF

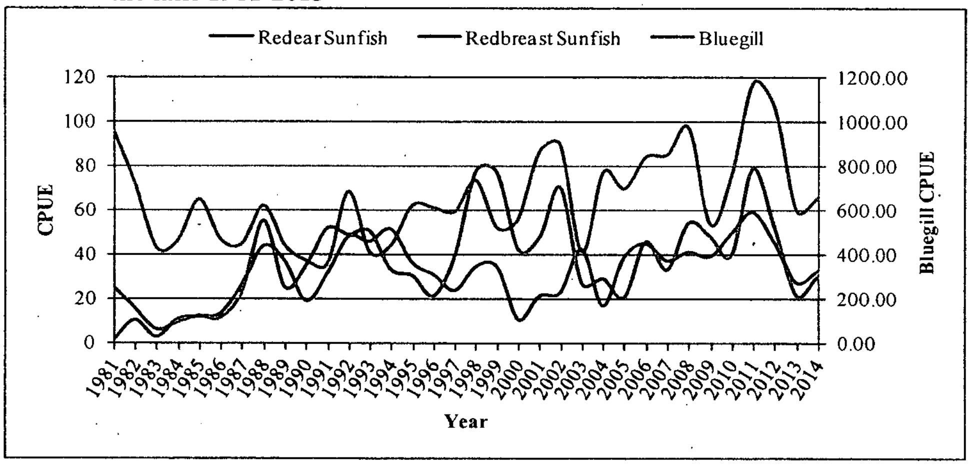
	Lake		
	2014	81-'13 Average	
Species	CPUE-N	CPUE-N	CPUE_N (p-value)
Lepomis macrochirus	654.08	651.37	0.944
Dorosoma petenense	94.00	3.56	0.000
*Lepomis cyanellus**	53.58	21.64	0.000
Lepomis microlophus	32.03	30.24	0.502
Lepomis auritus	29.94	38.10	0.024

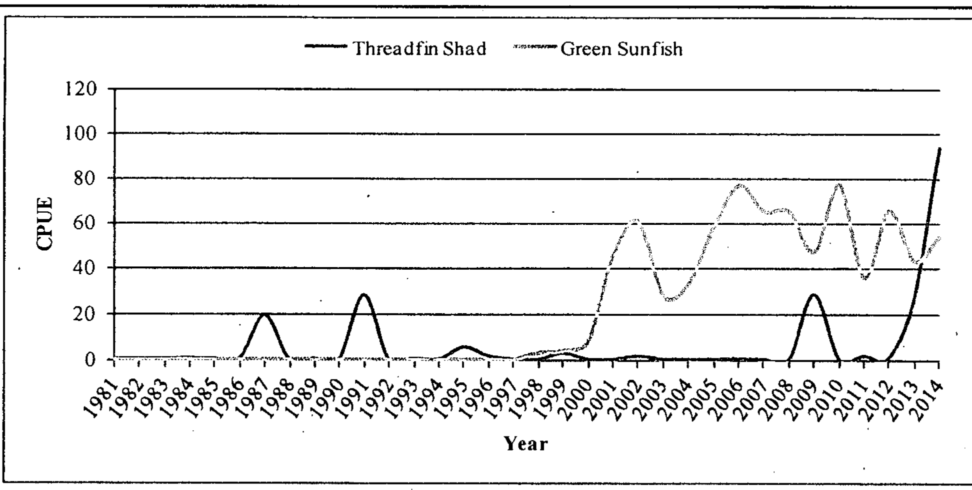
	WHTF		
	2014	81-'13 Average	
Species	CPUE-N	CPUE-N	CPUE_N (p-value)
Lepomis macrochirus	331.29	305.64	0.385
*Lepomis cyanellus**	59.21	25.79	0.000
Lepomis microlophus	29.98	18.59	0.000
Micropterus salmoides	25.48	20.58	0.020
Ictalurus punctatus	4.87	1.59	0.000

* *Lepomis cyanellus* first appeared in samples in 1997 in the WHTF and 1998 in the lake

In the lake, Threadfin Shad and Green Sunfish had a 2014 CPUE that was significantly higher than the 1981-2013 average and Redbreast Sunfish's CPUE was significantly lower than the historical average. The differences between Bluegill and Redear Sunfish and their historical averages were not significant. In the WHTF, Green Sunfish, Redear Sunfish, Largemouth Bass and Channel Catfish had a CPUE that was significantly higher than the 1981-2013 average and Bluegill had a catch rate that was not significantly different than the historical average. The CPUE for the 2014 numerically dominant electrofishing species in the lake and WHTF are displayed graphically from 1981-2013 in Figure 9 and Figure 10.

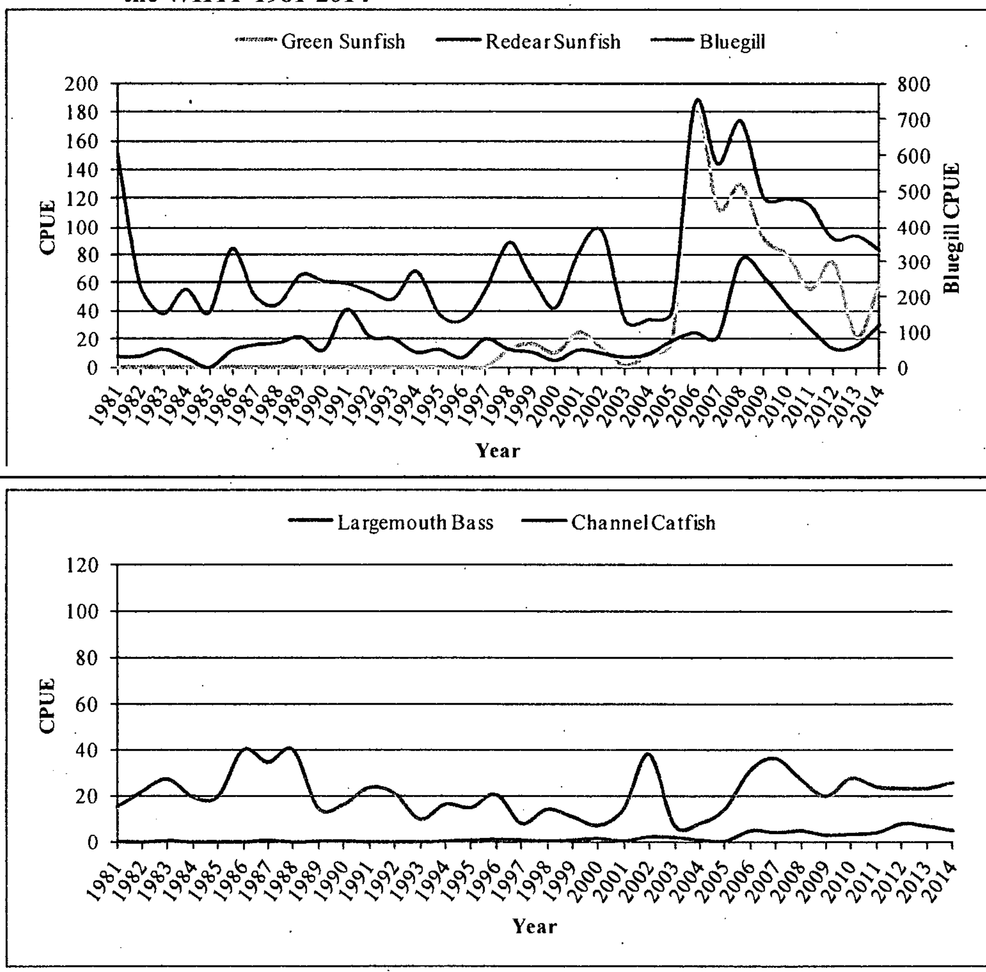
Figure 9 CPUE (#/hr) for the 2014 numerically dominant electrofishing species for the lake 1981-2013





In the lake, annual electrofishing CPUE for Bluegill and Redbreast has been on an increasing trend since its low in 1983 (429.25 and 6.32). Green Sunfish CPUE has also been on an increasing trend since its introduction in the lake, 1998, but it has recently appeared to be stabilizing around the historical average of 53.6 fish per hour. Redear Sunfish have consistently been seen in lake electrofishing samples while Threadfin Shad's presence in the samples has been more inconsistent. Redear Sunfish is a shoreline species and would be expected to be collected by electrofishing. Threadfin Shad are an open water (pelagic) fish which is less frequently seen in shallow water where our electrofishing samples are conducted. Periodically, large schools of shad are encountered and collected which inflates the catch rate which occurred in 2013 as well as 2014.

Figure 10 CPUE (#/hr) for the 2014 numerically dominant electrofishing species for the WHTF 1981-2014



Largemouth Bass CPUE in the WHTF has remained fairly stable with little variation among years. Green Sunfish and Bluegill catches in the WHTF have been on a decline since they reached a high of 182 and 739 fish per hour in 2006. Redear Sunfish CPUE in the WHTF has also been decreasing in the WHTF since 2008 where CPUE peaked at 76 fish per hour, but seem to be stabilizing at about 20-30 fish per hour with a 2014 catch rate of 29.9 fish per hour and a five year average of 25.8 fish per hour. Channel Catfish have been collected fairly consistently in WHTF electrofishing samples at very low catch rates but higher numbers are found in the gill net collections. This is because Channel Catfish are more susceptible to gill nets than electrofishing due to their tendency to inhabit deeper water. Although sunfish CPUE numbers have been decreasing in the last few years, they still remain the dominate species group in the WHTF electrofishing catches.

Biological systems are highly complex and are influenced by many environmental factors. It is difficult to determine exact causes of changes seen in sampling results especially since there are so many natural shifts in reproduction, growth, survival and distributions of aquatic organisms. Overall, electrofishing results in 2014 continue to show a balanced, indigenous fish community in the lake and WHTF and physicochemical parameters within the ranges to support a healthy fishery.

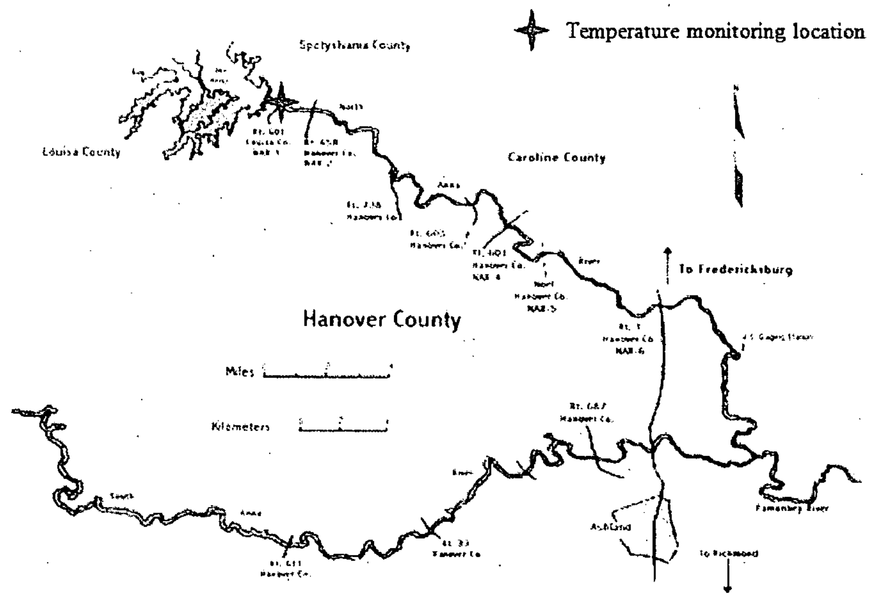
4.0 North Anna River

4.1 Temperature

<u>Methods</u>

Water temperatures (°C) were recorded hourly at station NAR-1 in the lower North Anna River during 2014 (Figure 11) using a Solinst Levelogger (±0.1°C) temperature recorder. Station NAR-1 is located approximately one kilometer below the Lake Anna dam.

Figure 11 Location of North Anna River temperature monitoring station



Results and Discussion

Temperature data from the North Anna River is summarized in Table 14. The maximum recorded temperature in 2014 was 31.9°C in July. The maximum mean monthly temperature was 29.1°C in July. Winter water temperatures at NAR-1 recorded in 2014 had a minimum monthly mean of 7.3°C recorded in February and a minimum hourly temperature of 5.5°C recorded in January.

Table 14 Mean, maximum and minimum hourly water temperatures (C) recorded in the North Anna River, at station NAR-1 by month during 2014. Sample size (n) equals the number of hourly observations recorded each month.

Month	Mean	MAX	MIN	N=
January	8.1	10.9	5.5	743
February	7.3	9.4	5.7	672
March	9.6	11.6	7.4	744
April	15.3	18.9	11.3	719
May	21.6	26.6	16.0	744
June	27.5	31.1	23.5	720
July	29.1	31.9	25.5	744
August	28.4	30.9	26.3	744
September	25.9	30.8	21.8	720
October	21.1	24.8	17.8	744
November	14.8	18.9	11.3	720
December	10.8	13.9	8.9	743

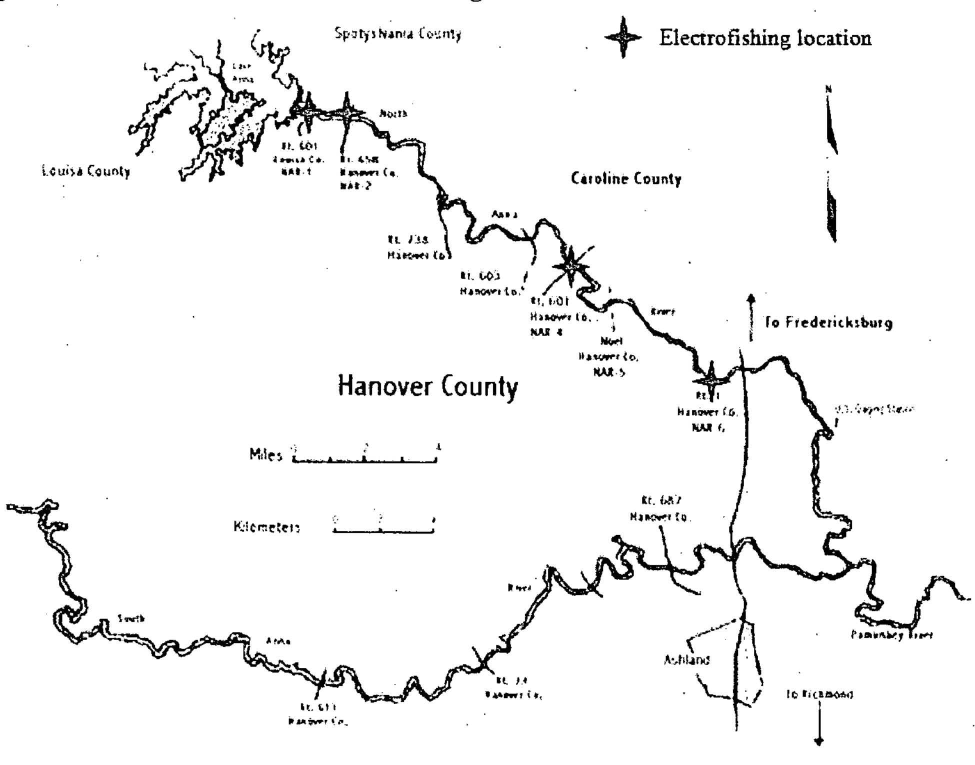
4.2 Fish Population Studies-Electrofishing

Methods

Abundance and species composition data for the North Anna River fish assemblage in 2014 were collected during electrofishing surveys. Consistent sampling techniques have been used in all North Anna River electrofishing surveys.

The locations of the four electrofishing stations are shown in Figure 12: NAR-1 (Route 601 Louisa Bridge); NAR-2 (Route 658 Bridge); NAR-4 (Route 601 Hanover Bridge); and NAR-6 (U.S Route 1 Bridge). An approximately 70 meter reach of riffle/run type habitat is sampled at each station with an electric seine. Prior to sampling, each reach is blocked at the downstream end with a 6.5-mm mesh net. Sampling is conducted by working the electric seine from bank to bank in a zigzag pattern from the upstream to the downstream end of the section. Nearby pool type habitats are then sampled for 10 minutes of effort with a backpack electrofisher. Fish sampled by electric seine and backpack electrofisher are collected using 6.5-mm mesh dip nets.

Figure 12 North Anna River Electrofishing Stations



Most fish collected are preserved in 10% formalin and transported to the laboratory for further processing. Some larger fish are weighed and measured in the field and released. In the laboratory, a maximum of 15 individual specimens of each species is weighed (g) and measured (mm-TL). If more than 15 specimens of a species are collected, those in excess of 15 are counted and weighed in bulk. Electric seine and backpack electrofisher collections were then pooled by station and survey month for analyses. Analysis was also performed by using the average number of fish caught by gear and survey (CPUE). CPUE for 2014 was compared to the historical means using a 1 sample t-test with a 95% CI.

Sample frequency for electrofishing is typically once per month each year in May, July and September. Consequently, this provides for a total of 24 river electrofishing collections for a typical sample year (May, July and September; 12 electric seine and 12 backpack). The May electrofishing samples were not conducted in 2014 due to rainfall, high water and unsafe river conditions.

Results and Discussion

Twenty-two species of fish representing eight families were collected by electrofishing in the North Anna River in 2014 (Table 15). Historically, (1990-2012), species richness in the North Anna River has remained high with a mean of 25.5 species. Species richness was highest at Station NAR-2 and NAR-4 in 2014, with 17 species collected at each station. Species richness at the other two stations ranged from 12 to 15 species per station.

Table 15. Fishes collected from the North Anna River during 2014 electrofishing surveys

Family	Species	NAR-1	NAR-2	NAR-4	NAR-6
Achiridae	*Trinectes maculatus*				x
Anguillidae	*Anguilla rostrata*	x	x	x	x
Catostomidae	*Hypentelium nigricans*		x	x	
Centrarchidae	*Lepomis auritus*	x	x	x	x
	Lepomis macrochirus			x	x
	Micropterus dolomieu			x	
	Micropterus salmoides	x	x		
Cyprinidae	*Cyprinella analostana*	x	x	x	x
	Lythrurus ardens	x	x	x	x
	Nocomis micropogon		x	x	x
	Notropis amoenus	x	x	x	x
	Notropis hudsonius	x		x	
	Notropis procne	x	x	x	
	Notropis rubellus	x	x	x	x
	Semotilus corporalis		x	x	
Ictaluridae	*Ictalurus punctatus*				x
	Noturus insignis	x	x	x	x
Percidae	*Etheostoma olmstedi*	x	x	x	x
	Percina notogramma		x	x	
	Percina peltata	x	x	x	x
Petromyzontidae	*Lethenteron appendix*		x		x
	Petromyzon marinus		x		x

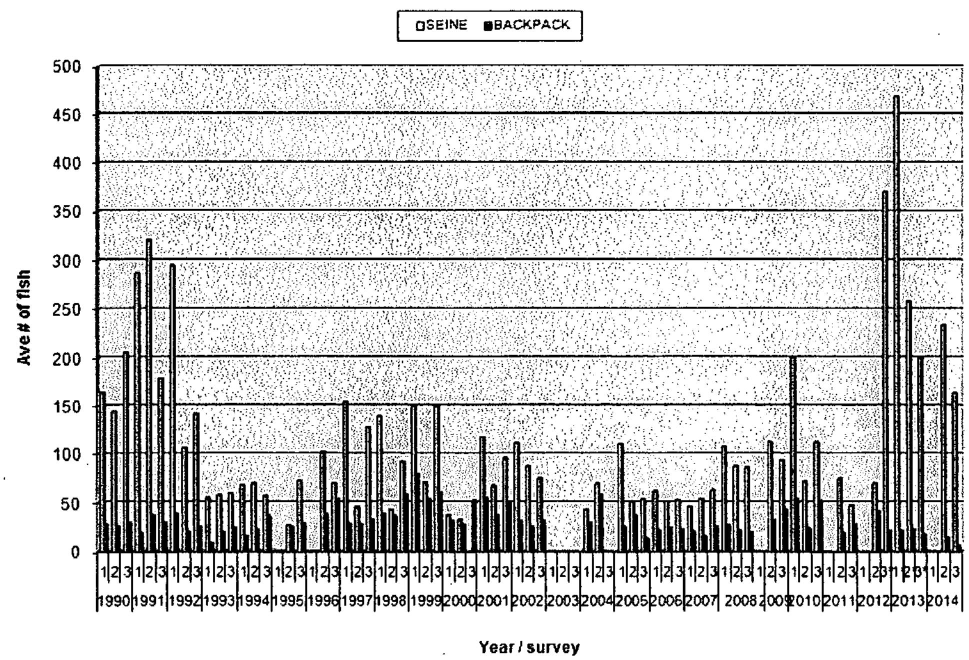
In 2014, a total of 1,731 fish weighing 12,732.2 g were collected by electrofishing in the North Anna River (Table 16). The total number of fish collected was highest at station NAR-1 and lowest at Station NAR-6.

Table 16 Number and weight (g) of fishes collected during July and October. 2014 electrofishing surveys of the North Anna River

		NAR-1		NAR-2		NAR-4		NAR-6		Total	
Family	Species	Number	Weight	Number	Weight	Number	Weight	Number	Weight	Number	Weight
Anguillidae	Anguilla rostrata	213	2792.8	25	946.7	58	941.4	8	66.4	304	4747.3
Cyprinidae	Cyprinella analostana	37	155.6	61	215.1	92	360.2	17	55.2	207	786.1
	Lythrurus ardens	149	426.4	70	126.6	18	57.6	35	48.7	272	659.3
	Nocomis micropogon			1	2.5	40	395.1	1	2.5	42	400.1
	Notropis amoenus	60	215.4	32	90.0	3	12.9	4	9.5	99	327.8
	Notropis hudsonius	8	54.4			1	2.8			9	57.2
	Notropis procne	2	3.6	105	142.7	8	13.2			115	159.5
	Notropis rubellus	30	113.3	44	147.3	25	48.2	7	10.2	106	319.0
	Semotilus corporalis			4	115.0	8	92.9			12	207.9
Percidae	Etheostoma olmstedi	8	9.8	6	3.9	5	9.4	12	10.2	31	33.3
	Percina notogramma			2	2.8	1	4.1			3	6.9
	Percina peltata	82	200.3	37	64.7	20	59.3	10	24.5	149	348.8
Catostomidae	Hypentelium nigricans			24	590.7	10	236.7			34	827.4
Ictaluridae	Ictalurus punctatus							2	5.1	2	5.1
	Noturus insignis	60	335.3	18	36.1	55	173.9	12	56.4	145	601.7
Centrarchidae	Lepomis auritus	38	428.4	62	996.1	42	888.2	28	266.9	170	2579.6
	Lepomis macrochirus					2	7.7	2	7.5	4	15.2
	Micropterus dolomieu					2	187.0			2	187.0
	Micropterus salmoides	2	8.6	3	367.0					5	375.6
Petromyzontidae	Lethenteron appendix			2	7.5			8	36.3	10	43.8
	Petromyzon marinus			1	4.7			8	34.1	9	38.8
Achiridae	Trinectes maculatus							1	4.8	1	4.8
Total		**689**	**4,743.9**	**497**	**3,859.4**	**390**	**3,490.6**	**155**	**638.3**	**1,731**	**12,732.2**

Since surveys and/or samples can be missed due to high flows, comparison of total fish numbers among surveys and years can be misleading. Therefore, a method to calculate the average number of fish caught per sampling station was developed and shows gear type, survey and year to represent a catch per unit effort (CPUE) to better compare fish numbers over time (Figure 13).

Figure 13 Average numbers of fish caught per station by survey, gear type and year 1990-2014



The minimum, maximum and mean CPUE per survey for the electric seine and backpack for years 1990-2013 are compared to CPUE for the electric seine and backpack for 2014 in Table 17. The mean CPUE per survey in 2014 was compared to the respective 1990-2013 mean using a one-sample t-test with a 95% confidence interval. The CPUE for the electric seine on surveys 2 and 3 in 2014 were 233.5 and 164 respectively. CPUE for both electric seine surveys in 2014 were significantly higher than the historical means with p-values <0.05 for each survey.

The CPUE for the backpack on surveys 2 and 3 in 2014 were 14.3 and 21.8 respectively. CPUE for both backpack surveys in 2014 were significantly lower than the historical means with p-values <0.05.

Electrofishing CPUE in the North Anna River is highly variable as can be seen from the large range of minimum and maximum CPUEs in Table 17. Although 2014 electrofishing CPUE was higher on some surveys and lower on others; species richness has remained high in the North Anna River samples.

Table 17 Fish CPUE Summary on the North Anna River 1990-2014

Electric Seine					
Survey	Min 1990-2013	Max 1990-2013	Mean 1990-2013	CPUE 2014	T test p-value
1	27.8	468.5	142.0		N/A
2	26.8	321.3	90.4	233.5	0.000
3	35.0	370.0	112.3	164.0	0.006

Backpack					
Survey	Min 1990-2013	Max 1990-2013	Mean 1990-2013	CPUE 2014	T test p-value
1	8.5	79.8	31.7		N/A
2	15.0	57.8	30.1	14.3	0.000
3	13.3	60.5	32.9	21.8	0.001

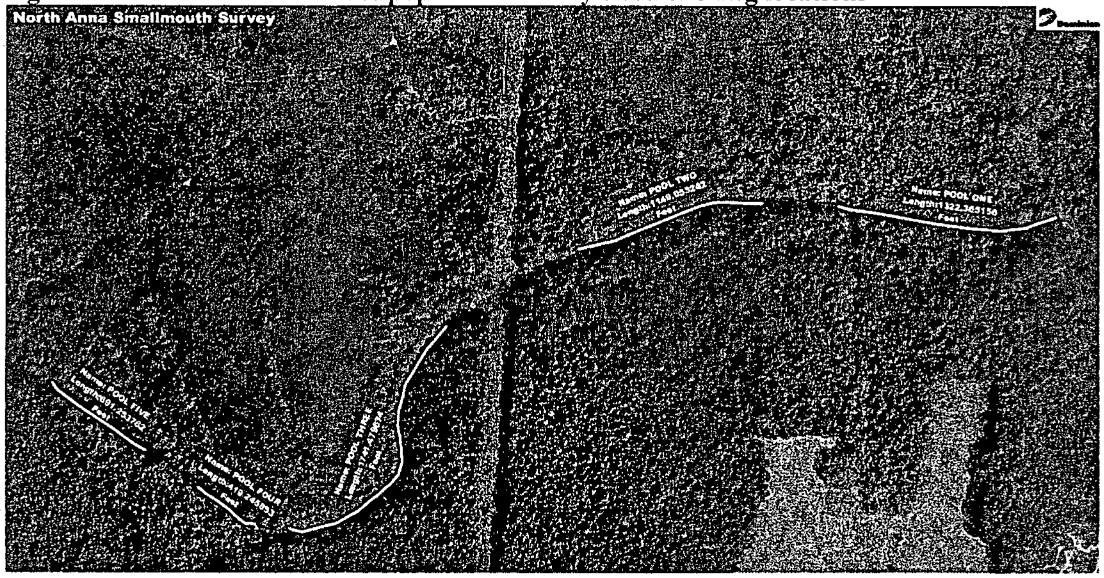
4.3 Smallmouth Bass

The DEQ approved monitoring plan for Lake Anna, WHTF and the lower North Anna River included a Smallmouth Bass *Micropterus dolomieu* study to assess the potential effects of water temperature and river discharge on spawning success of Smallmouth Bass in the North Anna River below the dam. In order to obtain a better understanding of Smallmouth Bass spawning success in the river in relation to physical variables (temperature and discharge), an attempt to collect a minimum of 50 young-of-year (YOY) was made in 2014. Otoliths from collected fish were examined by the Virginia Commonwealth University (VCU) Center for Environmental Studies to determine daily ages. In addition to the YOY sampling, a fall Smallmouth Bass survey was conducted to investigate and quantify the relative abundance of all size classes of Smallmouth Bass.

Methods

Summer Smallmouth Bass YOY collections and a fall Smallmouth Bass population sample were collected in 2014 by electrofishing. Smallmouth Bass YOY were collected in the vicinity of NAR-4 using a Zodiac electrofisher outfitted with a Smith-Root Type VI-A control box, a 5000W Honda generator and two handheld anodes. Smallmouth Bass of all sizes were collected for the population survey at a sequence of five pools in the vicinity of NAR-5, where the power lines cross the North Anna River in Noel, VA. These pools were consecutively sampled on 10/16/2014 using Zodiac boat electrofishing with a single boom umbrella array (Figure 13). Electrofishing was conducted in an upstream to downstream direction using pulsed DC. Sampling effort was measured by the amount of time that the electrofishing unit was energized and delivering current to the water. Bass were collected, measured for total length and released except for YOY bass. YOY bass collected from YOY sampling as well as the fall population sample were retained, frozen and sent to VCU for identification and aging.

Figure 14 Fall Smallmouth Bass population survey electrofishing locations



Back-calculation of spawning dates involved subtraction of the number of days required from spawning to swim-up (early stage of swimming up for food after absorption of egg or yolk sac is complete), days required from hatching to swim-up, and daily age from the Julian date of collection. River water temperature data from the NARIV601/NAR-1 continuous temperature logger were used for calculation of days required from hatching to swim-up. River water temperatures collected at NAR-1 were also used along with river discharge data, collected from the United States Geological Survey (USGS) gauging station 01670400 near Partlow, VA , to assess the potential effects of water temperature and river discharge on spawning success and spawning duration in the North Anna River. The accumulation of heating degree days (degree days) greater than 10°C was examined in relation to the beginning of the Smallmouth Bass spawning season, 2008-2014. The accumulation of degree days greater than 10°C was calculated from mean daily water temperatures and defined as the sum of the number of degree days greater than 10°C for all days previous to and including any particular day from 4/1 to 6/30 of any given year (Graham and Orth 1986). An example of how degree days were calculated is presented in Table 18.

Table 18 Example of Heating Degree Day Calculation

Date	Daily Average Water Temperature	Degree Days	Accumulated Degree Days
February 1, 2008	8.30	0.00	0.00
February 2, 2008	8.93	0.00	0.00
February 3, 2008	9.49	0.00	0.00
February 4, 2008	10.08	0.08	0.08
February 5, 2008	10.85	0.85	0.93
Februarv 6. 2008	11.69	1.69	2.62

Results and Discussion

Five Smallmouth Bass electrofishing surveys were conducted in 2014 during the months of July, August and October. Water temperature (°C) and dissolved oxygen (mg/L) from those surveys are presented in Table 19.

Table 19 Temperature and Dissolved Oxygen measurements recorded at time of Smallmouth Bass sampling at NAR-4 and NAR-5, North Anna River, 2014

Suvey	Date	Water Temperture	Dissolved Oxygen
YOY Collection	7/10/2014	27.20	7.80
YOY Collection	7/31/2014	22.01	8.50
YOY Collection	8/15/2014	22.70	7.50
YOY Collection	8/29/2014	23.14	7.62
Population Survey	10/16/2014	18.90	8.65

Smallmouth Bass spawning habitat on the North Anna River tends to be in areas with low water velocities up to 0.2 m/s and water depths in the range of 0.44 to 1.76 m (Lucas 1993). These conditions are usually found in pools and backwater areas which allow the male Smallmouth Bass to construct a depression or nest in the substrate where a female will deposit her eggs to be fertilized by the male. After fertilization, eggs hatch in approximately two days and swim-up usually occurs in one to two weeks. Mortality of YOY from predation is highest after swim-up when they first start actively feeding and have limited escape abilities (Tringali 2015). Disturbances to the nest, including high flows and predation, during this time will affect YOY Smallmouth Bass survival.

Figure 15 displays spawn dates for YOY Smallmouth Bass, accumulated degree days and river flow for years when YOY Smallmouth Bass were collected. No YOY were collected in 2009 due to multiple high flow events. River flows during the spawning season are variable and are highly dependent on spring rains and storms. Seventy-eight percent (78%) of the YOY that were collected in 2014 were spawned when river flows were less than or equal to 400 cfs. It has been suggested that flows less than 10 m^3/s (353 cfs) do not limit spawning habitat for smallmouth in the North Anna River (Lucas, 1993). Smallmouth Bass males often build nests near rocky or woody cover which tends to protect the nest and limit disturbances from waves, flow and reduces access by predators (Tringali 2015). Specific Smallmouth Bass nest locations may explain why some YOY may be able to survive periodic peaks in flow during the spawning season and others not.

Smallmouth Bass spawning is known to begin "when water temperatures exceed 15°C and degree-days greater than 10°C exceed 350" (Tringali 2015). On the North Anna River, the data shows spawning also beginning in each year when water temperatures exceed 15°C but four out of six years showed spawning occurring with degree-days less than 350 (Figure 15) with an overall average of 283.2 degree-days. Since Smallmouth Bass are known to inhabit both lakes and streams and have northern and southern populations, the 350 degree-days is general to the species and may not represent specific populations.

Figure 15 Estimated spawn date of YOY Smallmouth Bass, accumulated degree days (C) and river flow (cfs) on the North Anna River 2008, 2010-2014

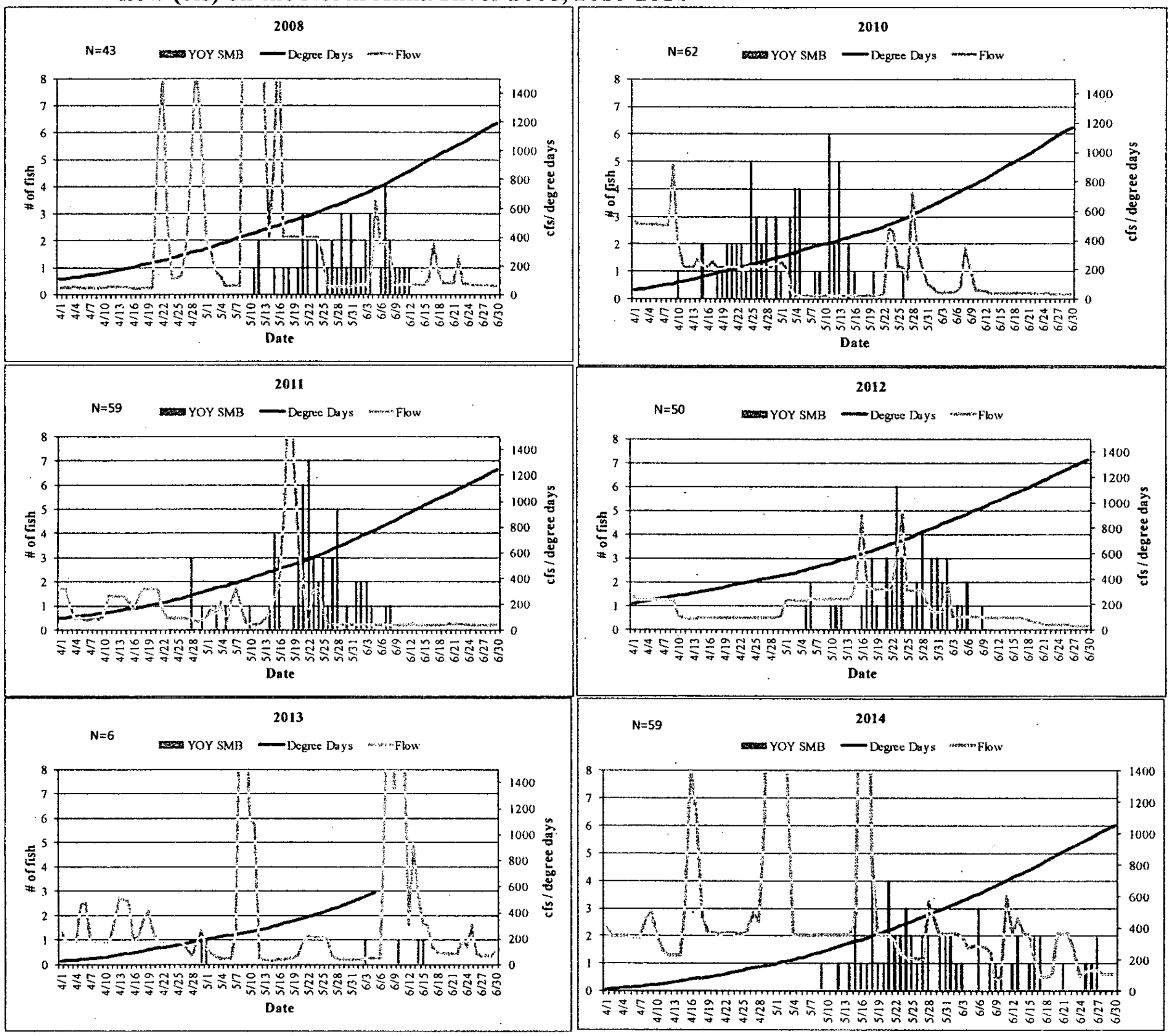


Table 20 Accumulated degree-days on the day of first spawn 2008-2014 *No YOY data due to high river flows

Year	Deg. Days Start
2008	427.2
2009	*
2010	108.5
2011	268.2
2012	466.8
2013	183.1
2014	245.4

In addition to the YOY analysis, data for adult and juvenile Smallmouth Bass caught on 10/16/2014 during the fall population sample at NAR-5 were analyzed. In 2014, 48 bass were collected at a rate of 25.4 fish per hour of electrofishing. Figure 16 displays the fish collected in 2014 by 50 mm length classes. When plotted the Smallmouth Bass lengths were normally distributed. CPUE (#/hr.) for each length class is presented in Table 21.

Figure 16 Length frequency distribution (50mm intervals) of Smallmouth Bass collected at NAR-5 on 10/16/14

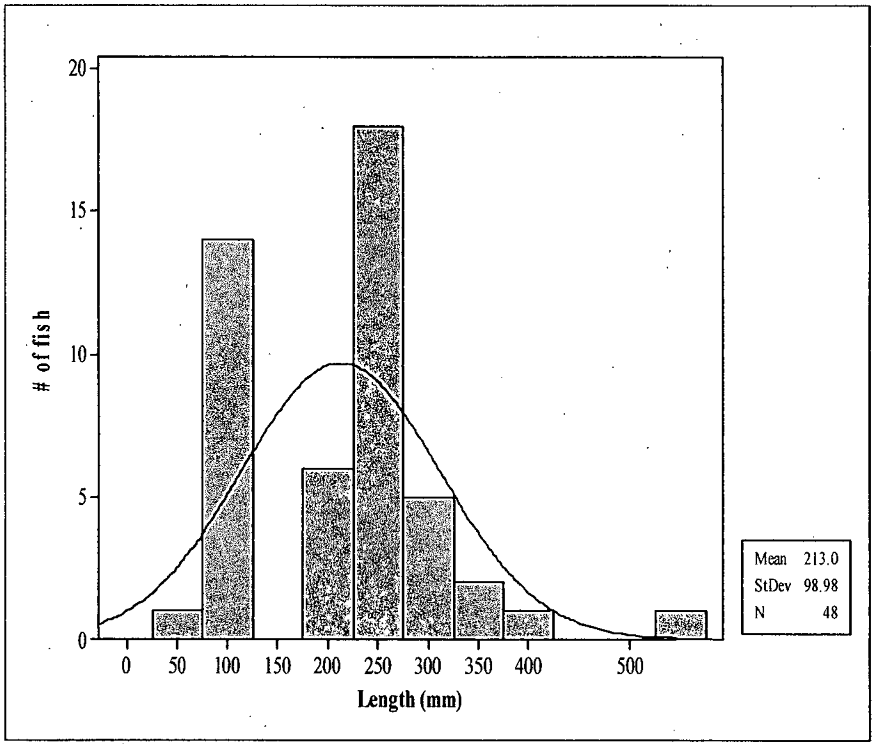


Table 21 CPUE (#/hr) of Smallmouth Bass per size class collected at NAR-5 on 10/16/14

Length Class (mm)	#	CPUE (#/hr)
25-75	1	0.5
75-125	14	7.4
125-175	0	0.0
175-225	6	3.2
225-275	18	9.5
275-325	5	2.6
325-375	2	1.1
375-425	1	0.5
525-575	1	0.5

Fifty percent (50%) of the bass fell into the 175-225 and the 225-275mm length classes with a combined catch rate of 12.7 fish per hour. YOY Smallmouth Bass fell into the 25-75 and 75-125 length classes and had a combined catch rate of 7.9 fish per hour. Smallmouth Bass in the 125-175 length class is missing from the catch in 2014. This missing group is comprised of age-1 bass. This year class was would have also been represented by the YOY catch in 2013 which was much lower than 2014 (7.4) with 2.1 fish per hour. This demonstrates the effectiveness of the population surveys to provide a relative abundance of the different size classes of Smallmouth Bass year to year. Boat electrofishing surveys will be continued to provide annual catch rates to gage year class strength. As the dataset increases, we should begin to identify what factors may be affecting the spawn and recruitment of Smallmouth Bass in the North Anna River.

5.0 Literature Cited

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